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ABSTRACT

The effect of motivational films on the attitudes of elementary school students (grades four, five, and six) was investigated by use of an attitude scale concerning science, scientists, and scientific careers. Some students were shown 10 films included in the Horizons of Science Film Program during a 10-week period. Follow-up activities used with subgroups of students included (1) discussion of multiple-choice questions distributed prior to the film, (2) group discussion led by the investigator, (3) discussion led by classroom teachers, and (4) no activity. The pre-test instrument was used to post-test all students included in the study. Attitudes of students in all experimental groups changed favorably from pre-test to post-test. Only the groups using the multiple-choice questions and those participating in investigator-led discussions showed significant gains over the groups which had not seen the films. The group using multiple-choice questions showed the most significant gain. There was no significant relationship between attitudes investigated and (1) grade level, (2) mental age, (3) mean and science achievement test scores, (4) sex, (5) parents' science backgrounds, and (6) economic status. (AG)

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The Pennsylvania State University

The Graduate School

Department of Secondary Education

The Effect of Three Methods of Treating Motivational Films Upon the Attitudes of Fourth-, Fifth-, and Sixth-Grade Students Toward Science, Scientists, and Scientific Careers

A Thesis in

Secondary Education

by

Roy W. Allison, Sr.

Submitted in partial fulfillment
of the requirements
for the degree of

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TABLE OF CONTENTS

Page

Acknowledgments ii

List of tables. v

I. INTRODUCTION
The Background of the Study 1
Statement of the Problem. 2
Hypothesis. 3
Sub-Problems. 3
Need for the Study. 4
Definition of Terms 9
Limitations of the Study. 12

II. REVIEW OF LITERATURE AND RELATED STUDIES
Purposes for the Review 13
Major Sources Consulted 13
Most Helpful Studies or Reports 14
Measurement of Attitudes. 15
Effect of Films on Attitudes. 18
Measurement of Attitudes Toward Science and Scientists. 26
Summary 40

III. PROCEDURES
Introduction. 42
The Films 42
The Control Group - Group A 43
An Experimental Group - Group B 43
An Experimental Group - Group C 43
An Experimental Group - Group D 44
An Experimental Group - Group E 45
Group F (Quasi-Control Group) 45
The Instrument. 46
The 9-Point Scale of Occupations. 52
Science Training of Parents 54
Procedure During the Experiment 54

IV. PRESENTATION AND ANALYSIS OF DATA
Introduction. 56
Preliminary Analysis. 56
Technique of Analysis 56
Test of Hypotheses. 60
Summary 92

Page

V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
Summary 100
Conclusions 102
Recommendations 107

BIBLIOGRAPHY. 108

APPENDIX A: Multiple-Choice Questions. 115

APPENDIX B: Discussion Materials 127

APPENDIX C: Allen Inventory of Attitudes Towards Science and Scientific Careers. . . . 150

APPENDIX D: Allison Adaptation of "Allen Attitude Scale". 156

LIST OF TABLES

TABLE Page

I. Table of Comparative Statistics Between the "Allen Attitude Scale" and the Allison Adaptation of "Allen Attitude Scale". 51

II. Comparison of Means, Standard Error of the Mean, Standard Deviation, and Sum of Squares for the Groups on the Pre-Test (Test 1), Post-Test (Test 2), and Retention-Test (Test 3) on the Allison Adaptation of "Allen Attitude Scale". 57

III. Summary of Experimental Data for Allison Adaptation of "Allen Attitude Scale" for All Experimental Sample Groups 61

IV. Matrix of t-Tests for Differences in Change of Attitude Between the Pre-Test and the Post-Test as Measured by the Allison Adaptation of "Allen Attitude Scale". 69

V. Matrix of t-Tests for Differences in Change of Attitude Between the Pre-Test and the Retention-Test as Measured by the Allison Adaptation of "Allen Attitude Scale". 69

VI. Table of t-Tests for Differences in Change of Attitude Between Pre-Test and Post-Test as Measured by the Allison Adaptation of "Allen Attitude Scale" Among the Fourth, Fifth, and Sixth Grades Within Each Treatment Group to Determine If a Particular Treatment Is More Effective at One Grade Level Than at Another Grade Level 72

VII. Table of t-Tests for Differences in Change of Attitude Between Pre-Test and Retention-Test as Measured by the Allison Adaptation of "Allen Attitude Scale" Among the Fourth, Fifth, and Sixth Grades Within Each Treatment Group to Determine If a Particular Treatment Is More Effective at One Grade Level Than at Another Grade Level 72

TABLE Page

VIII. A Matrix of r s for Group A Among Attitude Scores as Measured by Allison Adaptation of "Allen Attitude Scale," Change of Attitude, and Eight Factors Under Investigation 75

IX. A Matrix of r s for Group B Among Attitude Scores as Measured by Allison Adaptation of "Allen Attitude Scale," Change of Attitude, and Eight Factors Under Investigation 77

X. A Matrix of r s for Group C Among Attitude Scores as Measured by Allison Adaptation of "Allen Attitude Scale," Change of Attitude, and Eight Factors Under Investigation 79

XI. A Matrix of r s for Group D Among Attitude Scores as Measured by Allison Adaptation of "Allen Attitude Scale," Change of Attitude, and Eight Factors Under Investigation 81

XII. A Matrix of r s for Group E Among Attitude Scores as Measured by Allison Adaptation of "Allen Attitude Scale," Change of Attitude, and Eight Factors Under Investigation 83

XIII. A Matrix of r s for Group F Among Attitude Scores as Measured by Allison Adaptation of "Allen Attitude Scale," Change of Attitude, and Eight Factors Under Investigation 85

XIV. A Table of t-Tests of the Mean of the Differences in Attitude as Measured by the Allison Adaptation of "Allen Attitude Scale" for Each Treatment Group and Sub-Group. 93

CHAPTER I

INTRODUCTION

The Background of the Study

In the past, the selection of science and science-related careers has been left to natural selection procedures of the individuals involved. This incidental method of procurement of scientific personnel has not proven satisfactory. The institutions of higher learning have not been graduating the scientifically trained personnel not because of inadequate training facilities at any level but because students have not elected to take the training.

The student's election or selection of courses he would pursue in high school had traditionally been forced upon him and his parents at the end of the eighth grade or at the beginning of the ninth grade. The present trend is to ask that this election be made at still a lower grade level with the inauguration of track programs, programs of course acceleration, advanced placement courses, and other curricular changes being promoted from within and outside the field of science education. In order to elect or select the courses leading toward a scientific or science related career, the students should have a good understanding as well as a positive attitude toward science and the scientist. In fact, if a positive attitude toward science and the scientist can be created in most students to a level where they would pursue science further than they now do, it is possible we could raise the scientific literacy of the nation and narrow the gulf between the scientist and the non-scientist described by C. P. Snow in "Two Cultures."[1]

Can a positive attitude toward science and scientists be created in the minds of students? This study has attempted to assess the feasibility of using motivational films to promote a more positive attitude toward science and scientists in selected fourth-, fifth-, and sixth-grade students enrolled in the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania.

The selection of fourth-, fifth-, and sixth-grade students was intentional for two reasons. The first reason was that Welch[2] reported that career scientists recalled their interest in science had begun at the mean age of 12.5 years. The second reason was that the upper elementary grades are the years just before students begin more intensive training in the biological and physical sciences. For the above reasons this investigator felt that fourth-, fifth-, and sixth-grade students might profit most by an attempt to broaden their views about science and scientists.

Statement of the Problem

Can the attitudes of a selected group of fourth-, fifth-, and sixth-grade students concerning science, scientists, and scientific careers be changed favorably as a result of the treatments applied to ten motivational films which were viewed one each week?

---

[1] C. P. Snow, The Two Cultures and the Scientific Revolution (New York: The Rede Lecture, Cambridge University Press, 1959).

[2] Ellsworth W. Welch, "Motivational Factors in the Choice of Profession by American Scientists," Unpublished Doctoral dissertation (Stanford University, 1959).

Hypothesis

It will be possible to change the attitudes, as measured by the "Allen Attitude Scale"[3] adapted to be applicable at a fourth-grade level by the investigator, of fourth-, fifth-, and sixth-grade students.

Sub-Problems

1. Are changes in attitude related to the treatment given the experimental groups?

2. Are changes in attitude related to the grade level (fourth, fifth, sixth) of the student?

3. Are changes in attitude related to the student's mental age as measured by "The Lorge-Thorndike Intelligence Tests"?[4]

4. Are changes in attitude related to the mean of the achievement scores as measured by the "Stanford Achievement Test"?[5]

5. Are changes in attitude related to the science achievement

---

[3] Hugh Allen, Jr., Attitudes of Certain High School Seniors Toward Science and Scientific Careers (New York: Bureau of Publications, Teachers College, Columbia University, 1960).

[4] Irving Lorge and Robert L. Thorndike, "The Lorge-Thorndike Intelligence Tests" (Boston, Massachusetts: Houghton Mifflin Company, 1957).

[5] Truman L. Kelley, Richard Madden, Eric F. Gardner, and Herbert C. Reedman, "Stanford Achievement Test" (New York: Harcourt, Brace, and World, Inc., 1964).

score as measured by the "Stanford Achievement Test"?[6]

6. Are changes in attitude related to the sex of the student?

7. Are changes in attitude related to the student's plans to elect science?

8. Are changes in attitude related to science training of parents as recorded on the student's permanent record card?

9. Are changes in attitude related to the economic status of parents as determined by parents' job title recorded on student's permanent card?

Need for the Study

Education in general and science education in particular have been and remain the target of criticism of the public school systems in this post-Sputnik decade. Much of the criticism, though intended to be constructive, took the form of suggestions to (1) make the science courses presently offered more rigorous or (2) increase the number of science courses being offered or (3) both of these. Although the intent of these critics was, and is, to encourage greater numbers of our students to enter science or science-related fields, an increase in the rigor of a course like physics would only tend to keep more students away from the subjects and an increase in the number of courses could tend to reduce the enrollment in present courses instead of increasing total enrollment in science as was intended.

---

[6] Ibid.

It is assumed that this ferment for changes in science curriculum seemed to be initiated by the Russian launching of Sputnik. Agencies had been making recommendations for the improvement of science teaching. The National Society for the Study of Education (NSSE) is an example of one of these agencies. Committees of scientists and science educators had already started work on proposed changes in curriculum. The Physical Science Study Committee (PSSC), Biological Sciences Curriculum Study (BSCS), and Chemical Bond Approach Committee (CBA) are a few of the many examples of the cooperation of scientists, science educators, and secondary science teachers in making major curriculum revisions in physics, biology and chemistry respectively. The above curriculum groups felt they could engender a better understanding of science and the scientist through the new approaches than through the teaching of isolated facts and the verification of the classic experiments usually found in the traditional physics, biology, and chemistry courses. Perhaps only the students electing PSSC (physics), BSCS (biology), and CBA (chemistry) or similar new courses would be exposed to the approach designed to give them a better understanding of science and the scientist. Since they elect to take the course, the previously mentioned student probably had a wholesome, positive attitude toward science and the scientist and this attitude is merely strengthened.

Previous studies have been made concerning the attitudes exhibited by high school students toward science and the scientist.

An often quoted study by Mead and Metraux reported the following:

> The "official" image of the scientist - the answer which will be given without personal involvement - which was evoked primarily in Form I, but which recurs in the answers in all three forms, is a positive one.
>
> The scientist is seen as being essential to our national life and to the world; he is a great, brilliant, dedicated human being, with powers far beyond those of ordinary men, whose patient researches without regard to money or fame lead to medical cures, provide for technical progress, and protect us from attack. We need him and we should be grateful to him.
>
> . . . the positive image of very hard, only occasionally rewarding, very responsible work is also one which, while it is respected, has very little attraction for young Americans today.
>
> . . . The girls reject science, both as a possible form of work for themselves . . . and for their husbands . . . .[7]

It is interesting to note here that the foregoing report was pre-Sputnik and found, for the most part, a highly negative attitude toward science as a career choice. This negative attitude held by high school students, especially girls, could well be a factor regulating the supply of students matriculating in the science or engineering curricula in college.

A post-Sputnik study of the attitudes of high school seniors toward science and scientific careers by Hugh Allen, Jr., found that:

> 1. . . . it seemed reasonable to conclude that the students (when taken as a group) did possess attitudes favorable to science and the scientific endeavor in so far as these attitudes were measured by the instrument employed.

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[7] Margaret Mead and Rhoda Metraux, "Image of the Scientist Among High School Students--A Pilot Study," Science, 126:383 (August 30, 1957).

> 2. . . . many of the seniors included in the study did not fully understand the nature of science and scientific work.
>
> 3. While the image of the scientist which characterized the group as a whole seemed favorable and constructive, substantial numbers of the seniors (from 17 to 27 per cent) thought that scientists were too narrow in their views, too emotional, essentially magicians, and willing to sacrifice the welfare of others to further their own interests.
>
> 4. . . . it seems reasonable to conclude that there was no significant difference between the science and non-science groups in their attitudes toward the scientific enterprise as indicated by the instrument employed.[8]

The two studies, although reporting different findings, were in agreement that a need exists for the development of a means of creating a more positive attitude toward science and the scientist. Allen offers the following suggestions:

> The systematic use of insightful biographies of well-known scientists in regular class work, and the investigation of how scientists work and the sorts of problems they work on offer possibilities over the school years for helping children and young people to understand the scientist, the engineer, and similar professional workers.[9]

The "Horizons of Science Film Program," which is a series of ten films, each twenty minutes in length, presents a filmed field trip with an eminent scientist in each of the following scientific fields: anthropology, astronomy, atomic research, biochemistry, biophysics, electronics, mathematics, microbiology, oceanography, physiology, psychology, and space.[10] These films do precisely what Allen has suggested above.

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[8] Hugh Allen, Jr., Attitudes of Certain High School Seniors Toward Science and Scientific Careers (New York: Bureau of Publications, Teachers College, Columbia University, 1960), pp. 32-33.

[9] Ibid., p. 39.

Welch in his study, "Motivational Factors in Choice of Careers by American Scientists," found that the five hundred twelve scientists of his study indicated a mean age for first interest in science was 12.4 years. The need for developing a positive attitude toward science and the scientist before the age of twelve exists in order to promote an interest in scientific endeavor on the part of more children of this age to the end that more individuals will seek and secure training as science workers and scientists.[11]

Wickline, in his study, "The Effect of Motivational Films on the Attitudes and Understandings of High School Students Concerning Science and Scientists" was experimenting with motivational films in an attempt to change the attitude of high school students.[12]

The need for exploratory work in the formation of positive attitudes in elementary students is evident. Since we recognize that the American system of education adheres to the right of free career choice, regardless of change in the science courses and regardless of change in college entrance requirements, it may be assumed that students will not choose science or support scientific progress unless they hold a positive attitude toward science and the scientist. Discovery of methods of promoting positive attitudes could be valuable to science educators and help to recruit the science manpower needed in today's technological society.

---

[10] Horizons of Science (Princeton, New Jersey: Educational Testing Service).

[11] Ellsworth William Welch, "Motivational Factors in Choice of Profession by American Scientists," Unpublished Doctoral dissertation (California: Stanford University, 1959).

[12] Lee E. Wickline, "The Effect of Motivational Films on the Attitudes and Understandings of High School Students Concerning Science and Scientists," Unpublished Doctoral dissertation (University Park, Pennsylvania: The Pennsylvania State University, 1964).

Definition of Terms

The following terms, numbers 1-14, are taken from the Dictionary of Education (prepared under the auspices of Phi Delta Kappa), Carter V. Good, Editor (New York: McGraw Hill Book Company, Inc., 1959):

1. Attitude: a readiness to react toward or against some situation, person, or thing, in a particular manner--for example, with love or hate or fear or resentment--to a particular degree of intensity.

2. Attitude questionnaire: a series of questions focused on one or more specific attitude objects and designed to obtain a measure of the attitude or attitudes in question.

3. Attitude scale: an attitude-measuring instrument, the units of which have been experimentally determined and equated; designed to obtain a quantitative evaluation of an attitude: to be distinguished from attitude questionnaire, in which there is no such rational equality of units.

4. Attitude, scientific: a set of emotionally toned ideas about science and scientific method and related directly or indirectly to a course of action; in the literature of science education, the term implied such qualities of mind as intellectual curiosity, passion for truth, respect for evidence, and an appreciation of the necessity for free communication in science.

5. Attitude score: a quantitative score on an attitude scale; also, with less logical basis, often used to designate quantification of attitude questionnaires.

6. Attitude test: a test to measure the mental and emotional set or pattern of likes and dislikes held by an individual or group, often in relation to controversial issues, personal adjustments, etc.

7. Control group: (1) the one of two or more groups that is not subjected to the experimental factor or condition introduced into the treatment of the experimental group; (2) the group with which the experimental group or groups are compared.

8. Experimental group: (1) the one of two or more groups that is subjected to the experimental factor or condition, the effect of which it is the purpose of the experiment to discover; contrast with control group; (2) loosely, any of the groups in an experiment.

9. Inventory: in the field of evaluation, a test or check list used to determine the subject's or examinee's ability, achievement, aptitudes, interest, or likes, generally in a limited area.

10. Motivating device: any technique or situation used in

teaching for the primary purpose of stimulating interest and augmenting effort on the part of the pupils.

11. Motive: (1) broadly considered, any impulse, drive, attitude, whether conscious or not, that arouses, sustains, or regulates behavior; (2) an acquired disposition that is goal-directed as distinct from an unlearned physiological drive; (3) an internal motivation, such as an intention to act or a physiological drive, as distinguished from an incentive, which is external.

12. Motive, basic: an impulse, driving force, tendency, or motor attitude which is an inherent part of a person.

13. Mental age: (MA) the level of a person's mental ability expressed in terms of norms based on the median mental age of a group of persons having the same chronological age; thus, if a child's mental ability is equal to that of the average 9-year-old, he has a mental age of 9 years, regardless of his actual chronological age.

14. Score, achievement: the score made by a pupil on a subject-matter test or scale.

15. Motivation, film: any instructional plan that definitely utilizes film for the creation of interest in the process of learning.

16. The Allison adaptation[13] of "The Allen Attitude Scale" adapted by the investigator and used in the study.

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[13] See Appendix D.

Limitations of the Study

1. The study was limited to the students who were in fourth, fifth, and sixth grades of Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania, during the 1965-1966 school year. These students had a mean I. Q. of 116.8 and a mean of 6.31 on a 9-point scale of occupations used as a means to determine the economic status of the parents.

2. Each treatment of the experimental groups was further limited to the fourth-, fifth-, and sixth-grade classes assigned to the building in which that treatment was used.

3. The rooms provided in an elementary school were not always ideally suited to the showing of films.

CHAPTER II

REVIEW OF LITERATURE AND RELATED STUDIES

Purposes for the Review

The review of the literature was conducted in order to eliminate the possibility of repeating a previous study. Another purpose of the review was to gain knowledge of techniques and procedures which might prove useful in this study.

Major Sources Consulted

The following major sources of information were examined to locate publications which are pertinent to this study:

1. *Dissertation Abstracts*, University Microfilm, Ann Arbor, Michigan: 1950-1965.

2. *Doctoral Dissertations Accepted by the American Universities*, Association of Research Libraries, The H. W. Wilson Company, New York: 1950-1955

3. *Education Index*, The H. W. Wilson Company, New York: 1960-1965.

4. *Encyclopedia of Educational Research*, American Education Research Association, The Macmillan Company, New York: 1960.

5. *Instructional Film Research* (Rapid Mass Learning), Navexos P-977, Special Devices Center, Port Washington, L. I., New York: 1918-1950.

6. *Journal of Educational Research*, Dembar Publications, Madison, Wisconsin: 1950-1965.

7. _Journal of Experimental Education_, Dembar Publications, Madison, Wisconsin: 1950-1965.

8. Mary L. Lyda and Stanley B. Brown, "Research Studies in Education," _A Subject Index of Doctoral Dissertations, Reports, and Field Studies 1941-1951_, Boulder, (1953).

9. _Psychological Abstracts_, American Psychological Association, Lancaster, Pennsylvania: 1950-1965.

10. _Readers Guide to Periodical Literature_, The H. W. Wilson Company, New York: 1950-1965.

11. _Research in the Teaching of Science_, U. S. Department of Health, Education, and Welfare, Office of Education, U. S. Government Printing Office, Washington: 1959-1963.

12. _Review of Educational Research_, American Educational Research Association (NEA), Washington: 1950-1960.

13. _School Science and Mathematics_, Central Association of Science and Mathematics Teachers, Menasha, Wisconsin: 1950-1965.

14. _Science Education_, Science Education, Inc., Albany, New York: 1950-1965.

15. _The Science Teacher_, National Science Teachers Association, Washington: 1950-1965.

Most Helpful Studies or Reports

The published literature relative to attitude measurement and attitude change is voluminous. This review will concentrate on those studies, articles, and texts which relate to the three sub-titles which follow:

1. Measurement of Attitudes
2. Effect of Films on Attitudes
3. Measurement of Attitudes Toward Science and Scientists

Measurement of Attitudes

This investigator affirmatively agrees with the following:

> Probably the greatest problem in analyzing the relative effectiveness of various teaching methods stems from the difficulty of finding suitable tests for measuring changes in attitudes.[1]

It is agreed that an attitude is a construct not directly observable. Remmers says that attitudes are:

> The ways of looking at things and persons, forms of readiness, approaching and withdrawing behavior, feelings of rightness and wrongness, and liking or disliking for objects or values differ from emotions though they are related to them. They have been fused in the working concept of attitude which may be defined as an affectively toned idea or group of ideas predisposing the organism to action with reference to specific attitude objectives . . . attitudes are theoretically a component of all behavior, overt or covert.
>
> As thus defined the number of identifiable attitudes is the same as the number of things to which the organism can respond, and the concept is coterminous with, or closely related to, a considerable number of other psychological concepts, such as interests, appreciations, motives, mores, morality, morale, ideals, complexes (in the psychoanalytic sense), values, prejudices, fears, sentiments, loyalties, ideologies, character, and the like. From the point of view of society the system of morals and customs in operation is the social attitudes

---

[1] Lloyd K. Johnson, Ellsworth S. Obourn, and Blackwood, Research in the Teaching of Science (U. S. Department of Health, Education, and Welfare, U. S. Government Printing Office, Washington: 1965).

> which constitute the matrix of attitude patterns of the individuals in the society. From the point of view of the individual, attitudes consistute the individual's own evaluation of his conduct and desires in relation to the system of social values as he understands them.[2]

Some means of measurement or quantification is required to treat attitudes scientifically. In most cases, it is opinions, or expressed attitudes, which are actually measured. Remmers cautions that opinions may be different from underlying attitudes with or without the awareness of the subject (or the investigator). The assumptions implicit in attempts to measure attitudes are these, according to Remmers:

> . . . that attitudes are measurable, that they vary along a linear continuum, that measurable attitudes are common to the group, and that they are held by many people. Limitations of attitude measurements not implicit in these assumptions include the fact that they may be temporary and changeable and subject to rationalization and deception.[3]

On the subject of the influence of attitudes on behavior, Remmers says:

> . . . the realization is rapidly growing that attitudes, the way individuals and groups feel about various aspects of their world, are probably more determinative of behavior than more cognitive understanding of this world. When this is granted, the importance and value of attitude measurement becomes at once obvious.[4]

---

[2] H. H. Remmers, Introduction to Opinion and Attitude Measurement (New York: Harper and Brothers, 1954), pp. 3-4.

[3] Ibid., p. 7.

[4] Ibid., p. 15.

The attitudes reported by the Mead and Metraux[5] study were the result of an analysis of essays written by a nationwide sample of high school students. This represents, perhaps, the most difficult and cumbersome means of measuring attitudes. The findings of this study will be discussed later in the review under another section.

Thurstone's technique of scale construction seems to be less cumbersome than that used by Mead and Metraux. These efforts of L. L. Thurstone in the field of attitude measurement represent the first great breakthrough in this field. Thurstone's method for constructing attitude scales is described in The Measurement of Attitudes.[6] Thurstone's technique for scale construction was cumbersome for the following reasons: (1) it required a separate scale for each attitude object; (2) the scale construction was dependent upon the sorting of cards by a large number of judges.

The requirement of a separate scale for each attitude object was somewhat overcome by Remmers[7] when he developed a generalized scale capable of measuring attitudes toward any group or class of objects, but still using Thurstone's scaling techniques which involve the use of judges.

---

[5] Margaret Mead and Rhoda Metraux, "Image of the Scientist Among High School Students--A Pilot Study," Science, 126:384-390 (August 30, 1957).

[6] L. L. Thurstone and E. J. Chave, The Measurement of Attitudes (Chicago: University of Chicago Press, 1929).

[7] H H. Remmers (ed.), Studies in Attitudes, Studies in Higher Education (Lafayette, Indiana: Purdue University, 1934).

An attitude scale which did not require the use of judges was developed by Likert.[8] The Likert scale held many advantages over the Thurstone scale. These advantages were: (1) more easily constructed, (2) more easily administered, (3) more easily scored, and (4) did not require the use of judges. A high degree of correlation (.88) was observed between the Likert scale and the Thurstone scale. The Likert scale appeared to be as reliable as the Thurstone scale without the disadvantages of the Thurstone scale.

As attitude scales were developed and improved, experimentation involving attitude measurement and change could be attempted. The results of some of the studies, using these measures, will be reviewed in the two sections of the following discussion.

Effect of Films on Attitudes

As early as 1931 Thurstone attempted to measure changes in attitude as a result of viewing films when he reported an experiment to determine if children's attitudes toward the Chinese could be changed in the direction desired. Two films were shown, each in a different town; the first group viewed a film favorable to the Chinese and the second group viewed a film unfavorable to the Chinese. Thurstone's conclusions follow:

> The results show that the attitudes of the children were changed in opposite directions in the two towns,

---

[8] Rensis Likert, "A Technique for the Measurement of Attitudes," Archives of Psychology (New York: Columbia University, 1932, No. 140), p. 55.

> thus demonstrating the effect of the films as well as verifying the methods used . . . .
>
> The present experiments show experimentally that a single film has a measurable effect on the international attitudes of school children and that these attitudes can be measured by a statement scale.[9]

Thurstone continued his work and in 1933 Thurstone and Peterson in connection with the Payne Fund studies reported the effects of selected, then-current, entertainment films on attitudes toward Negroes, Chinese, Germans, crime, and criminals. In this group of studies Thurstone and Peterson were interested in (1) the effects of single films, (2) the cumulative effects of more than one film, and (3) the persistence of the effects being studied. The findings follow:

> Film Produced Unfavorable Attitude Toward Negroes
>
> The most striking influence of motion pictures on attitudes was reported in the study of the effect of D. W. Griffith's *Birth of a Nation*. This film, originally produced as a silent film, was revived in 1931 with the addition of a sound track. This film has been described as "anti-Negro." It was one of Griffith's most spectacular productions from a theatrical point of view and one of the most controversial motion pictures produced for public exhibition.
>
> Thurstone and Peterson reported that *Birth of a Nation* produced a modification of attitude toward the Negro in an unfavorable direction, and that this modification had the greatest magnitude of all effects observed in their studies of attitudinal influence of entertainment films. A mean change of 1.48 scale points on the attitude scale

---

[9] L. L. Thurstone, "Influence of Motion Pictures on Children's Attitudes," *Journal of Social Psychology*, Vol. II (1931), pp. 232-234.

(which extends from 0.0 to 10.6), with a critical ratio of 25.5 PE's, was found among the 434 students from grades six through twelve immediately after the film was shown. This change persisted, in diminished magnitude (.95), five months after the film was exhibited.

Film Modified Attitudes Toward Chinese

Favorable attitude changes were reported by Thurstone and Peterson with Sons of Gods, a film "favorable" to the Chinese. A mean change of 1.22 scale points (on a scale of values from 0.0 to 10.6) in the attitude toward Chinese was found immediately after the film experience, with the favorable effect persisting nineteen months later.

A slight, but statistically unreliable, change less favorable toward Chinese was found among high school students following exhibition of Welcome Danger. This film was a Harold Lloyd comedy, involving Tong conspirators and a lawless element of Chinatown. Thus, the element of comedy, the somewhat subordinate dramatic role assigned to Chinese, and possibly other variables were introduced. Whether these variables accounted for the absence of a reliable influence of this film on attitudes cannot be ascertained, since no film variables were considered in the Thurstone and Peterson studies other than the abstract quality of "favorable" or "unfavorable" film content.

Film Increased Favorable Attitudes Toward Germans

Four Sons, a film dealing with Germans and war, was shown to 133 students from grades seven through twelve. After seeing the film, the group was somewhat more favorable toward Germans on the Thurstone attitude scale. The mean difference before and after the film experience was .38 scale points (on a scale from 0.0 to 11.0), and the critical ratio, 5.37 PE's. Preference toward the German nationality shifted from fifth to second position on a preference scale.

The effects on attitude and preference persisted six months after the film experience. The experimental results may have been influenced somewhat by the novelty effect of the film experience, since the experimental population was drawn from a small town in Illinois in which entertainment motion pictures were not regularly exhibited.

Films Intensified Anti-War Attitudes

A slight anti-war influence was noted in connection with Four Sons. The before-after difference was .09 on the Thurstone scale. No critical ratio was reported, and it is assumed that this difference was not statistically reliable.

With both All Quiet on the Western Front and Journey's End, attitudes shifted reliably in an anti-war direction. The differences varied from .33 to .54 on the Thurstone scales. Critical ratios were all above five PE's.

The reliability of these attitude changes increased for those groups which saw both films. There was a significant persistence of effect for two months after exhibition, but this effect was less evident after four months.

Film Effects Were Cumulative and Persistent

High school and college students who saw The Criminal Code were less favorable toward punishment of criminals after seeing the film. The differences were approximately .50 on the Thurstone scale, and the critical ratios, above 11 PE's for both high school and college students. Thurstone and Peterson reported that 88 per cent of the effect persisted after two and a half months, and 78 per cent persisted after nine months.

When three films dealing with crime and criminals (Big House, Numbered Men, and Criminal Code), were shown to 745 students from grades six through twelve, the magnitude and reliability of attitudinal effects were greatest when the films were shown cumulatively. This effect remained constant after two months, and appeared to increase after four months. Thus, while it was found that an individual film might produce no change in attitude, the cumulative effect of seeing two or three films with similar bias at several-day intervals was observable.

The films, The Valiant and Alibi, had no reliable effect on the attitudes of children, drawn from grades seven through twelve, toward punishment of criminals. Hideout produced no measurable effect on the attitudes toward prohibition and bootlegging of 254 children, from grades nine through twelve. On the other hand, Street of Chance produced a "socially approved" effect, in that 240 children, drawn from grades nine through twelve, on taking a paired-comparison test, were more severe in their judgment of a

> gambler portrayed in the film, even though the gambler [illegible] presented as "an interesting, likeable character" (p. 15).[10]

Further studies of the effect of entertainment films were carried on by Shuttleworth and May as they investigated the reputation, conduct, and attitudes of "movie-going" children in grades five, six, seven, and eight and compared these children with "non-movie-going" children. The Shuttleworth and May study dealt with the measurement of general attitudes sometimes attributed to the nature of the entertainment films seen. They found no discriminable difference between the movie-going and non-movie-going children's general attitudes or opinion stereotypes. Any attitudinal differences found were specific rather than general in nature. It was found that, although entertainment films did not create general attitudes, the evidence pointed to the tendency of these movies to reinforce existing attitudes.

Other studies utilized documentary films as a means of influencing attitudes. One study by Ramseyer used four films, (1) "The Plow that Broke the Plains," (2) "The River," (3) Work Pays America," and (4) "Hands" as his film vehicles. The first two, (1) "The Plow that Broke the Plains" and (2) "The River," are historical landmarks in the history of the development of documentary films in the United States, having been produced for the U. S. Department of

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[10] Instructional Film Research (Rapid Mass Learning) Navexos P-977 (Special Devices Center, Port Washington, L. I., New York: 1918-1950), pp. 5-13 and 5-14.

Agriculture under the direction of Pare Lorentz with Virgil Thompson, composer of the musical score. The appeal of the first two films is consciously dramatic, and created attitude change favorable to government help with the problem of soil erosion. The latter two films, (3) "Work Pays America," and (4) "Hands" produced by the Works Progress Administration were more "factual" than the first two. They, too, produced reliable attitudinal changes in favor of the W. P. A. as reported by Ramseyer.[11]

A number of studies were reviewed which were concerned with the use of informational films on general attitudes. The first of these experiments by Bell, Cain, and Lamoreaux used eight "March of Time" films with experimental groups of fifth-, seventh-, ninth-, and eleventh-grade classes while the control classes in the same grades were taught the same information by their teachers. The results show reliable attitude changes in both the experimental and control groups with the ninth-grade groups being the only group evidencing a difference (2.6 standard errors) which was statistically significant in favor of the film group. In two other experimental studies conducted by Wilson and Larson[12] in Minnesota and by Cain[13] in California, attitude changes of a general character resulted after a short exposure of several weeks for both the film and non-film groups in both studies.

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[11] L. L. Ramseyer, "A Study of the Influence of Documentary Films on Social Attitudes," Unpublished Doctoral dissertation (Ohio State University, 1938).

[12] Instructional Film Research (Rapid Mass Learning), Navexos P-977, (Special Devices Center, Port Washington, L. I., New York: 1918-1950), pp. 5-18.

[13] Ibid.

As a result of some of the studies just reported in this section and some additional studies reported in the Instructional Film Research,[14] a summary of the effect of films on attitudes follows:

> 1. INFLUENCE ON SPECIFIC ATTITUDES
>
> The following conclusions about the influence of films on specific attitudes (closely related to the film content) are justified from the Thurstone and Peterson study:
>
> 1. Specific attitude changes can result from certain motion pictures whose content is closely related to the object of the specific attitude.
>
> 2. The effect of motion pictures on specific attitudes can be cumulative for two or more films on the same social theme. The cumulative effect may result even though some films in the sequence may be individually ineffective in reliably influencing a specific attitude.
>
> 3. When the initial influence of one or more motion pictures on a specific attitude is large and of high reliability, it may persist for several weeks or months, generally, although not necessarily, with some diminution.
>
> The Thurstone and Peterson study suggests the hypothesis, and Jones' and Ramseyer's data seem to confirm it, that few, if any, specific attitude changes will result when the film bias is strongly contradictory to the social norms. In the case of contradictory influences, film bias may actually reinforce the existing attitude, rather than modify it.
>
> Further, Ramseyer's data indicate that films may not exert the same attitudinal influence within a non-uniform population, such as one in which different occupational, social, or educational backgrounds are represented.

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[14] Ibid.

2. INFLUENCE ON GENERAL ATTITUDES

There are several conclusions, largely tentative, which may be inferred from the experimental evidence on the influence of specific motion pictures on general attitudes:

1. The attitudinal influences of a single motion picture appear to be specific, rather than general.

2. The cumulative effect of a series of motion pictures is probably general, but the effect is subject to the following conditions:

    a. The films are all biased in the same direction and are consistent with the general predisposition of the audience.

    b. They are exhibited in a context that supports and reinforces the direction of the bias.

    c. The exhibition of the films is spaced over a period of time.

There is, however, no direct evidence that motion pictures are reliably superior to other media of communication in their influence on general attitudes. Some evidence exists to the contrary. If the conclusions regarding the impact of films on the learning of information could be generalized to attitudes (and there is no evidence to support such generalization), it might be postulated that the force of motion pictures on general attitudes may be greater than that of verbal media alone, when the influence is measured in long-term effects and when conditions required in the development of general attitudes are satisfied. This postulate is somewhat feasible when reminiscent effect is taken into consideration, and when a relationship between specific and general attitude is assumed. However, research is needed on the long-term attitudinal effects of films to substantiate this postulate.[15]

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[15] Ibid.

Measurement of Attitudes Toward Science and Scientists

The opinion of this investigator is that the attitude any student possesses toward science as a discipline and toward the scientist is bound to have an effect upon his choice of a career and the support he is willing to give scientific endeavors as a taxpayer and voter. Although there is a need for more and better people to become leaders in science and technology, the need is still greater in this, the space age, to have an enlightened citizenry which can cast its ballots more intelligently in light of the possible consequences of an alternative choice.

A search has been in progress in recent years for ways to expose more students to the best teachers in order to gain the highest achievement scores possible by cramming more and more minutiae into the students' minds. A degree of success has been noted by the many studies which have, as a control group, a conventionally taught class or classes and as an experimental group, a class or classes being taught the same materials through one of the mass media (radio, television, or films). In a great number of these studies, the results show that the experimental group's achievement is equal to, or sometimes superior to, the achievement of the control group. More recent studies have found that even though there are no detrimental effects to achievement, there are harmful side results which will be described in the paragraphs immediately following.

Sheehan's[16] study of fifth-grade instruction of natural science by television in the Boston area is a prime example of adverse side effects. The primary purpose of the study was to measure the effect of different methods of utilizing the teaching of natural sciences by television upon achievement. The change of attitude among these students in the fifth grade was also measured to see how the students' interest in science and attitude toward science and scientists would change as a result of the utilization of television to teach natural science. The control groups taught by conventional (a classroom teacher) method exhibited a slight increase in interest in science and in attitude toward science and the scientists. The experimental groups taught through full utilization and varying degrees of partial utilization of television to teach the same material had slight decreases in interest in science and in attitude toward science and scientists. The results indicated that a significant difference in attitude did not exist between the experimental and control groups. However, even the slightest negative shift in attitude is an undesirable effect.

An experiment involving the teaching of college chemistry by lecture demonstration (control group) and by television (experimental group) had similar results. Miller[17] reported that there were no significant differences in achievement, but a measure of the student's attitude toward instruction resulted in significant differences in favor of live lectures. The student attitude findings showed that the television teacher was considered less personable than the classroom teacher. Similar results were found on student attitude toward their interest and learning and toward their motivation and effort when television teaching was compared with live classroom instruction.

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[16] Cornelia A. Sheehan, "The Interrelationships of Interests and Attitudes and Specified Independent Variables in the Teaching of Natural Science by Television in the Fifth Grade," Unpublished Doctoral dissertation (Boston University School of Education, 1960).

A study involving the experimental use of films to teach physics and chemistry in a secondary school was reported by Black.[18] The attitudes of the film groups in both chemistry and physics, when compared with the pupils in the non-film group, were significantly unfavorable toward the respective subjects at the end of the experiment.

Many studies have reported finding negative attitudes toward science and scientists. The five studies which follow are typical and include the two most highly publicized and often quoted studies of this group, the Purdue Opinion Panel Poll and the Mead and Metraux study.

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[17] Adam W. Miller, Jr. "The Effectiveness of College Chemistry Instruction by Television," Unpublished study. (Montana State College, Bozeman, 1959).

[18] William A. Black and others, "The Effectiveness of Filmed Science Courses in Public Secondary Schools," Science Education, 45:327-335 (October 1962).

The Purdue Opinion Panel Poll[19] investigated aptitudes and attitudes of secondary school students toward occupations. Many of the students responding admitted that they were poorly informed about scientists and their work. It was assumed that this lack of information accounted for the negative attitudes toward science and scientists. The responses of the students to four items are as follows: (1) 45% felt their academic background was too poor to allow them to choose a career in science, (2) 37% felt that a scientist would sacrifice the welfare of others to further scientific interests, (3) 35% felt that to be a scientist you must be a genius, (4) 30% felt that a scientist could not raise a normal family.

Remmers and Radler[20] in polling a nationwide sample of high school students in 1957 on their ideas and feelings concerning science and scientists found that (1) 35% felt that to be a good scientist it is necessary to be a genius, (2) 30% felt that scientists cannot raise a normal family, (3) 38% felt that scientists do not have time to enjoy life, and (4) 25% felt that scientists are willing to sacrifice the welfare of others to further their own interests. Although the percentage responses of this study do not concur with the foregoing Purdue Opinion Poll, the attitudes toward scientists expressed by the students polled by these two studies are the same.

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[19] P. C. Baker, R. W. Heath, H. W. Stoker, and H. H. Remmers, "Physical Science Aptitude and Attitudes Toward Occupations," The Purdue Opinion Panel Poll, No. 45 (Lafayette, Indiana: Division of Educational Reference, Purdue University, July 1956).

[20] H. H. Remmers and D. H. Radler, The American Teenager, (Indianapolis-New York: Bobbs Merrill Co., 1957).

Bendig and Mountres[21] reported a particularly disturbing study of college students' stereotype of the research scientist, since the college students displaying the stereotype were education majors who will be our future teachers. If it is possible to transmit the stereotype displayed by these future teachers from teacher to student, we may continue to have difficulty in interesting students to pursue scientific careers. Bendig and Mountres reported that the stereotypes held by the college sophomore education majors about the personality traits of scientists, engineers, businessmen, and lawyers were as follows:

1. Scientists and lawyers have more intellectual traits than engineers and businessmen.

2. Lawyers and businessmen have more desirable interpersonal relationships than do scientists and engineers. And in comparing the research scientist with the other three occupations, the college sophomores felt that the research scientist was the most intellectual, studious, thorough, orderly, precise, and persistent and yet the same college sophomores felt that the research scientist would have the least poise, self-confidence, charm, humor, and friendly nature.

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[21] A. W. Bendig and P. T. Mountres, "College Student Stereotypes of the Personality Traits of Research Scientists," Journal of Educational Psychology, Vol. 49 (December 1958), pp. 309-314.

O'Dowd and Beardslee[22] found that scientists rate lowest of fifteen high-level occupations on sociability. The strong features of the image of the scientist reported in this study were his high intelligence and his driving concern to extend knowledge and to discover truth. Many disturbing weaknesses in the image of the scientist were reported. The scientist was described as uninterested in people and unsuccessful in his relationships with them. He was viewed as uninterested in art, a nonconformist, and a radical. The students admitted that they respect the scientist's intelligence, but regarded him as a social nonconformist.

The image of the scientist as reported by Mead and Metraux is broken into three parts as follows:

THE SCIENTIST

THE SHARED IMAGE

> The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle-aged and wears glasses. He is small, sometimes small and stout, or tall and thin. He may be bald. He may wear a beard, may be unshaven and unkempt. He may be stooped and tired.
>
> He is surrounded by equipment: test tubes, bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials. The sparkling white laboratory is full of sounds: the bubbling of liquids in test tubes and flasks, the squeaks and squeals of laboratory animals, the muttering voice of the scientist.
>
> He spends his days doing experiments. He pours chemicals from one test tube into another. He peers rapidly through

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[22] D. D. O'Dowd and D. C. Beardslee, "Student Images of a Selected Group of Occupations and Professions," Science, 133:997-1001 (March 1961).

microscopes. He scans the heavens through a telescope (or a microscope!). He experiments with plants and animals, cutting them apart, injecting serum into animals. He writes neatly in black notebooks.

The image then diverges.

THE SCIENTIST

POSITIVE SIDE OF THE IMAGE

He is a very intelligent man - a genius or almost a genius. He has long years of expensive training - in high school, college, or technical school, or perhaps even beyond - during which he studied very hard. He is interested in his work and takes it seriously. He is careful, patient, devoted, courageous, open-minded. He knows his subject. He records his experiments carefully, does not jump to conclusions, and stands up for his ideas even when attacked. He works for long hours in the laboratory, sometimes day and night, going without food and sleep. He . . .

THE SCIENTIST

NEGATIVE SIDE OF THE IMAGE

The scientist is a brain. He spends his days indoors, sitting in a laboratory, pouring things from one test tube into another. His work is uninteresting, dull, monotonous, tedious, time-consuming, and, though he works for years, he may see no results or may fail, and he is likely to receive neither adequate recompense nor recognition. He may live in a cold-water flat; his laboratory may be dingy . . . .

His work may be dangerous. Chemicals may explode. He may be hurt by radiation, or may die. If he does medical research, he may bring home disease, or may use himself as a guinea pig, or may even accidentally kill someone . . . .

He neglects his family - pays no attention to his wife, never plays with his children. He has no social life, no other intellectual interest, no hobbies or relaxations. He bores his wife, his children and their friends . . . .

> A scientist should not marry. No one wants to be such a scientist or to marry him.[23]

On the basis of their data, Mead and Metraux made many recommendations--some of which follow:

> Mass media. Straight across the country there is a reflection of the mass media image of the scientist, which shares with the school materials the responsibility for the present image. Alterations in the mass media can have important consequences in correcting the present distorted image if such changes are related to real conditions. Attempts to alter the image, in which the public relations department of a particular company represents its research personnel with crew cuts and five children, may improve the recruitment program of single companies, but do so only at the expense of intensifying the negative aspects of the image for the country as a whole.
>
> What is needed in the mass media is more emphasis on the real, human rewards of science - on the way in which scientists today work in groups, share common problems, and are neither "cogs in a machine" nor "lonely" and "isolated." Pictures of scientific activities of groups, working together, drawing in people of different nations, of both sexes and all ages, people who take delight in their work, could do a great deal of good.
>
> The mass media could also help to break down the sense of discontinuity between the scientist and other men, by showing science as a field of endeavor in which many skills, applied and pure, skills of observation and of patient, exact tabulation, flashes of insight, delight in the pure detail of handling a substance or a material, skills in orchestrating many talents and temperaments, are all important. This would help to bring about an understanding of science

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[23] Margaret Mead and Rhoda Metraux, "Image of the Scientist Among High School Students--A Pilot Study," Science, 126:384-390 (August 30, 1957), pp. 386-387.

> as a part of life, not divorced from it, a vineyard in which there is a place for many kinds of workers.[24]

Their results also suggested to Mead and Metraux the following changes which might be introduced into educational planning:

> 1. Encourage more participation and less passive watching in the classroom, less repeating of experiments, the answers to which are known . . . .
>
> 2. Begin in the kindergarten and elementary grades to open children's eyes to the wonder and delight in the natural world, which can then supply the motive power for enjoyment of intellectual life later . . . .
>
> 3. Teach mathematical principles much earlier, and throughout the teaching of mathematics emphasize nonverbal awareness: let children have an opportunity to rediscover mathematical principles for themselves.
>
> 4. Emphasize group projects; let the students have an opportunity to see science as team work, where minds and skills of different sorts complement one another.
>
> 5. Emphasize the need for the teacher who enjoys and is proficient in science subjects, irrespective of that teacher's sex; this would mean that good women teachers could be enlisted instead of depending on men, irrespective of their proficiency. Since it would seem that the boys do not need to identify with an adult male as a teacher, this should leave us free to draw on women as a source of science teachers.
>
> 6. Change the teaching and counseling emphasis in schools which now discourage girls who are interested in science . . . .
>
> 7. De-emphasize individual representatives of science . . . . Instead, emphasize the sciences as fields, and the history of science as a great adventure of mankind as a whole . . . .

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[24] Margaret Mead and Rhoda Metraux, "Image of the Scientist Among High School Students--A Pilot Study," Science, 126:384-390 (August 30, 1957), pp. 388-389.

> 8. Avoid talking about the scientist, science, and the scientific method. Use instead the names of the sciences - biology, physics, physiology, psychology - and speak of what a biologist or a physicist does and what the many different methods of science are - observation, measurement, hypotheses-generating, hypotheses-testing, experiment.
>
> 9. Emphasize the life sciences and living things - not just laboratory animals, but also plants and animals in nature - and living human beings, contemporary peoples, living children . . . .[25]

If the only studies available on the subject of attitudes were those just reviewed, the need to create a positive attitude toward science and the scientist would indeed be a critical one. There are studies whose findings have presented us with an entirely different picture of student attitudes concerning science and the scientist.

Belt[26] measured and compared the attitudes of high ability high school students with the attitudes of a cross-sectional sample of high school students. The instrument he used contained Likert-type statements. Twenty of the statements he used were the same as twenty statements used on the Purdue Opinion Panel Poll. Belt compared the percentage responses he obtained with those reported by the Purdue Opinion Panel Poll and the results indicate that relatively high-ability students have attitudes more favorable toward science and scientists than would a cross section sample of all high school students. The conclusions drawn indicate that the high-ability, college-bound, high school pupils of this study have sufficient academic ability to pursue an education in the sciences and also have indicated positive attitudes toward science and scientists. We could, therefore, infer that since they have a positive attitude toward science and scientists, they could choose science as a career. Belt's report does not support either the findings or the implications drawn from some of the literature previously discussed.

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[25] Margaret Mead and Rhoda Metraux, "Image of the Scientist Among High School Students--A Pilot Study," Science, 126:384-390 (August 30, 1957), p. 389.

[26] Sidney L. Belt, "Measuring Attitudes of Pupils Toward Science and Scientists," Unpublished Doctoral dissertation (Rutgers, The State University, 1959).

A study was made of the attitudes of high school seniors toward science and scientists by Allen[27] in New Jersey. His findings were that the students possessed attitudes which were favorable to science and the scientific endeavor. In the opinion of the investigator, the responses of some of the high school seniors seem to indicate that they do not fully understand the nature of science and scientific work.

Klopfer and Cooley[28] found that student understandings of science and scientists can be measured. They further reported that activities planned in order to change these understandings of science and scientists were successful. Since understandings are closely related to attitudes, a change in understanding through motivational activity could promote a corresponding change in attitude.

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[27] Hugh Allen, Jr., Attitudes of Certain High School Seniors Toward Science and Scientific Careers (New York: Bureau of Publications, Teachers College, Columbia University, 1960), pp. 47-52.

[28] Leopold E. Klopfer and William W. Cooley, Use of Case Histories in the Development of Student Understanding of Science and Scientists (Cambridge, Massachusetts: Harvard University, 1961).

An experimental study to change the attitudes of youngsters toward certain conservation topics by Williamson and Remmers[29] used 300 youngsters of different ages with both rural and urban backgrounds. Their reported findings were:

1. Attitudes can be changed significantly.
2. Attitudes once changed by stimulus materials will persist for up to eight months or more.
3. Attitudes became less homogeneous after stimulus materials were presented than before.
4. Attitudes of the urban group were changed more by the stimulus material than were the attitudes of the rural group.

Weisgerber[30] reported that his use of motivational films did not significantly influence the attitudes of junior high general science students toward science or scientists. The films did change the attitudes of tenth-grade biology students toward their science classes but left no significant change in tenth-graders toward (1) the use of films in science courses, (2) the work a scientist does, and (3) the students' science teachers.

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[29] A. C. Williamson and H. H. Remmers, "Persistence of Attitudes Concerning Conservation Issues," *Journal of Experimental Education*, Vol. VIII (1940), pp. 334-361.

[30] Robert A. Weisgerber, "Motivation for Science," *The Science Teacher*, Vol. XXVIII, No. 1 (February 1961), pp. 20-23.

Wickline[31] found that his use of motivational films did not significantly influence the attitudes of high school students toward science and scientists. He did, however, indicate that the students in his study admitted that their first science interest had begun around fourth, fifth, or sixth grade. He suggests that his study be tried at a lower level.

Welch[32] polled approximately 500 scientists regarding their choice of a scientific career. He found that a great number of his respondents credited a teacher with initiating the first interest in science and also exerting the greatest influence. The mean age of first interest (to the best of the respondents' memories) was 12.5 years and the mean age at which most respondents claimed to have made the choice of the career they were in was 16.7 years.

Edgerton[33] studied the relationship of Science Talent Search examination scores with several factors. Relative scores of students were compared by high school size, pairing two students with the same scores who came from different size high schools. On the average it was found that those who stayed in science as a career came from larger high schools than those who chose a nonscientific career field. When the size of the score was compared to the highest degree held, it was found that those with highest scores were most likely to attain the higher degrees in college. Edgerton had some findings similar to those reported by Welch. The people in Edgerton's study reported that (1) teachers were the major influence in choosing a science career (except physicians who reported the home most influential), (2) students leaned toward science careers early, for some as early as second or third grade, and (3) none of the 136 Science Talent Search Winners who were interviewed changed his early choice of science as a professional career, although some reported changing within areas of science.

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[31] Lee E. Wickline, "The Effect of Motivational Films on the Attitudes and Understandings of High School Students Concerning Science and Scientists," Unpublished Doctoral dissertation (University Park, Pennsylvania: The Pennsylvania State University, 1964).

[32] Ellsworth W. Welch, "Motivational Factors in the Choice of Profession by American Scientists," Unpublished Doctoral dissertation (Stanford University, 1959).

[33] Harold A. Edgerton, Science Talent, Its Early Identification and Continuing Development (Washington: Science Service, Inc., 1719 N St., N. W., 1960).

MacCurdy[34] reported that science interest begins in the elementary school years. This first science interest is highly influential in the occupational choices of the people interviewed. MacCurdy interviewed entrants of a State Science Fair for three consecutive years. First science interest was originally associated with free play, pets, and scientific toys. Teachers and schools have become more influential with most of this influence on science interest concentrated on group, teacher-directed, and vicarious activities.

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[34] Robert D. MacCurdy, "Science Interest Grows," Science Education, 44:401-407 (December 1960).

Summary

In the foregoing review of the literature this investigator has attempted to acquaint the reader with previous related studies and knowledge of techniques and procedures which could prove useful in this study. This review has been subdivided into the following:

1. Measurement of Attitudes
2. Effect of Films on Attitudes
3. Measurement of Attitudes Toward Science and Scientists

Under the first subdivision the investigator attempted to give a brief history of the development of attitude measuring instruments from the difficult-to-score instruments developed and used by L. L. Thurstone to the equally good but more easily constructed, administered, and scored instruments developed by R. Likert. The attitude instrument adapted by this investigator to be used in this study is of the Likert type.

Under the second subdivision the investigator attempted to show the preponderance of experimental proof already available to the effect that films are capable of changing attitudes in a desired direction. This investigator used a series of ten motivational films in an attempt to favorably change the attitudes of fourth-, fifth-, and sixth-grade students toward science and scientists.

Under the third subdivision three topics were reviewed. The first of these topics included those studies which claimed that the presently held student attitudes toward science and scientists are negative attitudes. The second of these topics included those studies which claimed that the presently held attitudes of students toward science and scientists are positive attitudes, and also those studies which reported attempts to change attitudes toward science and scientists. The third of these topics included those studies which have attempted to identify the time at which the first and also the most influential interest in the selection of science as a career of scientists was evidenced.

Since respondents to many studies indicated elementary school as the age at which the scientists in the studies indicated that they first became interested in science as a career choice, this investigator felt that the use of motivational films might create more positive attitudes in fourth-, fifth-, and sixth-grade students toward science, scientists, and scientific careers. The use of these motivational films should also have provided vicarious science experiences with noted scientists. These vicarious experiences of viewing these films also should have helped these children to understand the nature of science and the job of a scientist.

CHAPTER III

PROCEDURES

Introduction

This chapter contains the procedures used in gathering the data for the study and an explanation of these procedures.

The Films

> Horizons of Science is an educational film program to help provide broad scientific education of both non-scientists, and future scientists and engineers. To stir imaginations, broaden understanding and stimulate thinking are the major purposes of the Horizons of Science series. New knowledge from scientific research--basic principles, complex concepts, newly formulated theory, supporting evidence--much of which is not readily available elsewhere permeates the program. Each film is an enriching educational experience.
>
> The film program, in ten releases, is a direct link between exciting ideas of science--penetration to the earth's mantle, conquest of space, evolution in microscopic life--the men and women who develop and act upon these ideas, and the students in the schools who all too infrequently are caught up in the excitement of ideas. Students who experience each of the films in the Horizons of Science series--their parents and teachers--are put in intimate contact with a prominent scientist or scientific team working at the forefront of knowledge. Imaginations are stirred. Interest in the work of the scientist is stimulated. Ten such experiences in the course of a year bring the student to the realization that science contains a series of ever-widening horizons, all demanding intelligent consideration.
>
> At the junior high school level curriculum decisions usually are made which "freeze" students for their remaining secondary school years. The Horizons of Science experience helps students make intelligent choice of subjects and appropriate decisions as to course.[1]

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[1] *Horizons of Science* (Princeton, New Jersey: Educational Testing Service).

The Control Group - Group A

The control group consisted of the fourth-, fifth-, and sixth-grade students enrolled in the Wilmer F. Loomis School, one of the elementary schools of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The students used in the control group had a mean I. Q. of 115.5 with a standard deviation of 14.2 and a mean of 6.17 with a standard deviation of 1.66 on a 9-point scale[2] of occupations used as a means to determine the economic status of the parents. The pupils in this group did not see the films or have any special treatment.

An Experimental Group - Group B

The experimental group consisted of the fourth-, fifth-, and sixth-grade students enrolled in the Marple Elementary School, one of the elementary schools of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The students used in experimental Group B had a mean I. Q. of 115.3 with a standard deviation of 12.3 and a mean of 6.18 with a standard deviation of 1.60 on a 9-point scale of occupations used as a means to determine the economic status of the parents. The pupils in this group viewed each of the ten films without comment or without any special treatment.

An Experimental Group - Group C

The experimental group consisted of the fourth-, fifth-, and sixth-grade students enrolled in the Culbertson Elementary School, one of the elementary schools of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The students used in experimental Group C had a mean I. Q. of 118.3 with a standard deviation of 13.7 and a mean of 6.68 with a standard deviation of 1.50 on a 9-point scale of occupations used as a means to determine the economic status of the parents. The pupils in this group were given a series of multiple-choice questions found in Appendix A to read prior to the time they viewed each of the ten films. After viewing each film they answered the questions, they submitted their answers, and their teachers went over each question indicating the correct choice. These students were permitted to keep the question sheets.

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[2] See pages 52 and 53.

An Experimental Group - Group D

The experimental group consisted of the fourth-, fifth-, and sixth-grade students enrolled in the Jay W. Worrall School, one of the elementary schools of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The students used in experimental Group D had a mean I. Q. of 116.4 with a standard deviation of 12.7 and a mean of 6.44 with a standard deviation of 1.54 on a 9-point scale of occupations used as a means to determine the economic status of the parents. The pupils in this group viewed each of the ten films and discussed each film immediately following the film showing. The investigator led the discussion with the entire experimental group using the discussion materials found in Appendix B.

An Experimental Group - Group E

The experimental group consisted of the fourth-, fifth-, and sixth-grade students enrolled in the Charles H. Russell School, one of the elementary schools of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The students used in experimental Group E had a mean I. Q. of 119.8 with a standard deviation of 13.8 and a mean of 6.48 with a standard deviation of 1.41 on a 9-point scale of occupations used as a means to determine the economic status of the parents. The pupils in this group viewed each of the ten films and discussed each film immediately following the film showing. Each classroom teacher led the discussion with his class using the discussion materials found in Appendix B.

Group F (Quasi-Control Group)

Group F consisted of the fourth-, fifth-, and sixth-grade students enrolled in the Alice Grim School, one of the elementary schools of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The students used in Group F had a mean I. Q. of 115.1 with a standard deviation of 15.4 and a mean of 5.88 with a standard deviation of 1.84 on a 9-point scale of occupations used as a means of determining the economic status of the parents. This group was not considered as either an experimental or control group at the onset of the experiment. Therefore, no serious attempt was made to keep all factors, other than the use of films and the treatment of these films, constant. This group did not view the films; therefore, it could qualify as a control group in this respect. However, the fourth- and fifth-grade students of this group had a greater number of demonstration lessons and large group instruction sessions with the investigator, who was the science consultant, than any other group. The use of the science consultant in the classroom was kept constant in groups A, B, C, D, and E. The investigator felt that the results for this group should be reported as a control group, with the notation that the use of the science consultant was the only factor not controlled.

The Instrument

Since the investigator wished to work in the area of change in attitude toward science and scientists, an instrument which would measure this dimension was desirable. A search of the literature revealed no instrument written at the desired level (fourth-, fifth-, and sixth-grades) for the elementary school students to be tested; however, a research instrument similar to the one desired but written for high school seniors was located and the author, Hugh Allen, Jr., granted permission to use his test, the "Allen Inventory of Attitudes Toward Science and Scientific Careers." The developer of the instrument has presented evidence of content validity and construct validity and in determining positive, constructive attitudes says:

> Implied in all phases of the study was the notion that attitudes favorable to science could be identified. To determine the positiveness or negativeness of the attitudes of the total sample and of certain subgroups, several scientists and professors of science served as a jury of

experts. These judges were selected for their long experience in science and science teaching, and because they were conveniently located in the metropolitan area.

The 95 items of the attitude scale were placed on cards. Each judge was given a set of these cards, and instructed to arrange them in a series extending from very favorable to scientific endeavor to very unfavorable to scientific endeavor. The rank of each item for each judge was determined, and a score (sum) was obtained for all judges for each item. These scores were then ranked, and a percentage position was obtained for each item. After obtaining this percentage position, a given item was assigned a scale score between zero and ten, zero being totally favorable to science, and ten being wholly unfavorable. Using a normal distribution curve, this places the mean for the judges at 5.0.

Table 1 gives the correlation between the judges' responses and their scaled scores. The correlations are high, especially those of the individual judges with the scale score.

TABLE 1: CORRELATION BETWEEN JUDGES' RESPONSES AND SCALE SCORE

JUDGES[a]	1	2	3	4	5	6	SCALE[b]
1	___	.695	.731	.683	.689	.767	.860
2		___	.707	.653	.755	.825	857
3			___	.607	.704	.743	.849
4				___	.699	.689	.813
5					___	.757	.876
6						___	.890
SCALE							___

[a] X for judges = 48.00
S for judges = 27.42

[b] X for scale = 5.01
S for scale = 1.90

By treating the judges' responses in this manner, it was possible to make comparisons and compute correlations between the expressed opinions and attitudes of the students and the judges so as to estimate the extent to which the responses

> of the high school seniors studied were favorable and constructive with respect to the scientific enterprise.[3]

A log of the steps the investigator took to adapt the "Allen Attitude Scale" written for high school seniors to its present form follows:

Permission to adapt the "Allen Inventory of Attitudes Toward Science and Scientific Careers" was granted by Hugh Allen, Jr. The investigator used *A Teacher's Word Book of 30,000 Words*[4] to change the wording of the statements on the attitude inventory to a fourth-grade vocabulary. One hundred four fourth-grade students in the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania, were asked to identify (by drawing a circle around) any words that they did not understand. Helene Cochrane and Mary Kapros, reading consultants of the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania, used the "Botel Readability Formula" to determine the reading level of the adapted attitude inventory. Any word identified by ten or more students as a word that they did not understand was replaced with simplified language. All of the words the reading consultants identified as being too difficult were replaced.

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[3] Hugh Allen, Jr., *Attitudes of Certain High School Seniors Toward Science and Scientific Careers* (New York: Bureau of Publications, Teachers College, Columbia University, 1960), pp. 8-9.

[4] Edward Thorndike and Irving Lorge, *A Teacher's Word Book of 30,000 Words* (New York: Teachers College, Columbia University, 1944).

The final form of the Allison adaptation of the "Allen Inventory of Attitudes Toward Science and Scientific Careers" was given to a group of thirty-nine high school seniors in the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania. The same group of thirty-nine students took the "Allen Inventory of Attitudes Toward Science and Scientific Careers." The correlation between the scores on the two attitude inventories was r = .81.

The final form of the Allison adaptation of the "Allen Inventory of Attitudes Toward Science and Scientific Careers" was given to groups of fourth-, fifth-, and sixth-grade students in the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania, to determine the reliability of the instrument for measuring attitudes commensurate with the level at which the investigator planned to use the instrument.

The investigator claims the adapted instrument has a high degree of construct validity and measures the same construct (attitude) as does the "Allen Inventory of Attitudes Toward Science and Scientific Careers" as indicated by the Pearson Product moment (r = .81) between the adapted instrument and the original "Allen Inventory of Attitudes Toward Science and Scientific Careers." If simplifying the language of the items on the instrument did not change the meaning of the statements, the new instrument can claim the same degree of content validity as follows:

> Preliminary to preparing the attitude scale, the investigator reviewed current periodicals which expressed

> many points of view on scientific endeavor, and made special note of derogatory statements from various sources. Following this, a list of questions was formulated for interviews with scientists and professors of sciences, and with high-ability high school students who were planning either scientific or nonscientific careers. These interviews were used as a basis for the formulation of the 95-item scale included in Section III of the inventory. The statements selected were subsequently classified by the investigator into categories so that the attitudinal responses might be analyzed relative to specific aspects of scientific endeavor. The order of items on this scale was analyzed and found to be satisfactory, and the correlation between placement and other variables was low in each instance.[5]

The simplification of the language improved the reliability of the instrument as calculated by the Kuder-Richardson formula 20 and tabulated on the table which follows on page 51.

In order to dichotomize the response pattern for the attitude scale as required by the Digitek Optical Test Scoring Machine, it was necessary to utilize two scoring keys. Key number one (K-1 on the table) has as the correct response the most positive (totally disagree or completely agree) attitude and Key number two (K-2 on the table) has as the correct response a more moderate (partially disagree or partially agree) positive attitude.

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[5] Hugh Allen, Jr., Attitudes of Certain High School Seniors Toward Science and Scientific Careers (New York: Bureau of Publications, Teachers College, Columbia University, 1960), p. 7.

TABLE I

TABLE OF COMPARATIVE STATISTICS BETWEEN THE "ALLEN ATTITUDE SCALE"[6] AND THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE"

	Grade 12 Allen	Grade 12 Allison	Grade 6 Allison	Grade 5 Allison	Grade 4 Allison
1. K-1	.411	.406	.253	.286	.238
1. K-2	.279	.298	.123	.209	.207
2. K-1	.422	.509	.674	.589	.466
2. K-2	.377	.482	.515	.453	.419
3. K-1	.162	.162	.162	.162	.162
3. K-2	.162	.162	.162	.162	.162
4. K-1	.178	.259	.454	.347	.217
4. K-2	.142	.232	.265	.205	.175
5. K-1	.918	.946	.974	.963	.929
5. K-2	.881	.934	.930	.921	.903
6. K-1	39.00	38.54	24.00	27.21	22.62
6. K-2	26.51	28.28	11.72	19.87	19.64
7. K-1	214.79	309.04	449.84	358.75	196.09
7. K-2	141.73	274.63	124.16	171.27	140.82
8. K-1	14.66	17.58	21.21	18.94	14.00
8. K-2	11.91	15.74	11.14	13.09	11.87

1. Mean Difficulty of the items on this test
2. The Average item--total score correlations for the questions in this test
3. Standard Error of correlation
4. Estimated Interitem correlation
5. Kuder-Richardson 20 Reliability
6. Test mean
7. Variance
8. Standard Deviation

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[6] *Allen Inventory of Attitudes Toward Science and Scientific Careers*, Science Manpower Project, Teachers College, Columbia University, New York, Copyright 1959, used with permission by the author.

The 9-Point Scale of Occupations

In order to determine the economic status of the students, the investigator chose a 9-point scale of occupational stratification described by Centers who says:

> Occupation seems generally agreed upon as the most satisfactory single index, probably because it is more objective than economic status (which depends to a certain extent on a rater's judgment) and is more easily and more reliably ascertained than income.[7]

The investigator used as his source of information the pupil permanent records in which the occupation of the parent is recorded. This information was then applied to the scale values of categories of occupational stratification Centers described as follows:

Scale Value	Occupation
8	Large Business
7	Professional
6	Small Business
5	White Collar Workers
4	Farm Owners and Managers
3	Skilled Workers and Foremen
2	Farm Tenants
1	Semi-Skilled Workers
0	Unskilled Workers and Farm Labor[8]

It was necessary to alter the above scale values by adding one to each of the scale values because the data were to be analyzed by computer techniques which at times consider zero data as missing data.

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[7] Richard Centers, The Psychology of Social Classes, A Study of Class Consciousness (Princeton, New Jersey: Princeton University Press, 1949), p. 15.

[8] Ibid., p. 51.

The following information was compiled to further describe the occupation categories. The sources of this information are Centers[9] and *Dictionary of Occupational Titles*.[10]

Category	Includes
1. Unskilled Workers and Farm Labor	Construction workers, garage laborers, janitors, maintenance men, porters, sweepers . . .
2. Semi-Skilled Workers	Bartenders, bus drivers, driver salesmen, machine operators, painters, service station attendants, truck drivers, waiters . . .
3. Farm Tenants	
4. Skilled Workers and Foremen	Bakers, barbers, carpenters, cooks, electricians, foremen, machinists, masons, meatcutters, mechanics, PBX installers, plumbers, printers, tool and dye . . .
5. Farm Owners and Managers	
6. White Collar Workers	Accountants, agents, auditors, buyers, clerks and kindred workers, draftsmen-designers, freight conductors, insurance men, salesmen, sales managers, semi-professional workers, technicians . . .
7. Small Business (includes both owners and managers)	Brokers, builders, contractors, merchants, repair shops employing others, small retail dealers . . .

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[9] *Ibid*., p. 49.

[10] *Dictionary of Occupational Titles*, U. S. Employment Service (Washington: Superintendent of Documents, Revised 1949).

8. Professional	Artists, dentists, engineers, lawyers, ministers, musicians, physicians, professors, teachers . . .
9. Large Business	Bankers, large department store owners and managers, manufacturers . . .

Science Training of Parents

The science training of parents was determined from the information regarding job title and amount of education completed recorded on the student's permanent record card. This information was translated into a dichotomous variable on the student data cards used in the analysis of data.

Procedure During the Experiment

Groups A, B, C, D, E, and F were pre-tested with the Allison adaptation of the "Allen Attitude Scale" in September, 1965.

Group A did not view the films.

Groups B, C, D, and E viewed one of the "Horizons of Science"[11] film series each week for ten weeks beginning in September, 1965.

The students in Group B viewed the films only.

The students in Group C each received a series of multiple-choice questions to read prior to the time they viewed each of the ten films. After viewing each film they answered the questions, submitted their answers, and then their teachers went over each question indicating the correct choice. These students were permitted to keep the question sheets.

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[11] Horizons of Science (Princeton, New Jersey: Educational Testing Service).

The students in Group D viewed each of the ten films and discussed each film immediately following the showing of the film. The investigator led the discussion with the entire experimental Group D present using the discussion materials found in Appendix B.

The students in Group E viewed each of the ten films and discussed each film immediately following the showing of the film. The classroom teachers led the discussion with their classes using the discussion materials found in Appendix B.

Group F did not view the films.

Groups A, B, C, D, E, and F were post-tested with the Allison adaptation of the "Allen Attitude Scale" in December, 1965 at the conclusion of the showing of the ten films.

Groups A, B, C, D, E, and F were tested again in April, 1966 at the end of ten additional weeks to check for retention of any attitude gain.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Introduction

This chapter contains the steps taken during the analysis of data and tables of the findings of this analysis.

Preliminary Analysis

A single data card for each student was prepared containing all the information about that student required for the study. These student data cards were used to obtain the necessary statistics, such as, mean, standard deviation, standard error of the mean, and sum of squares for the three testing situations involving the Allison adaptation of the "Allen Attitude Scale."

The I. B. M. 1410 and I. B. M. 7074 computers at The Pennsylvania State University Computation Center were used to do the computation of these preliminary statistics. The program used by the computers was PSU Computation Center library program (11.0.011) entitled "Statistical Summary" written by G. W. Gorsline. Table II on pages 57, 58, and 59 contains the results of the preliminary analysis.

Technique of Analysis

The investigator utilized the results of the preliminary analysis and computed some of the tests of significant difference with a Monroe (Model CSA-10) Automatic Calculator.

TABLE II

COMPARISON OF MEANS, STANDARD ERROR OF THE MEAN, STANDARD DEVIATION, AND SUM OF SQUARES FOR THE GROUPS ON THE PRE-TEST (TEST 1), POST-TEST (TEST 2), AND RETENTION-TEST (TEST 3) ON THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE"

Group	Test	Means	Standard Error of the Mean	Standard Deviation	Sum of Squares
Group A	Test 1	316.44	2.6150	22.034	33985.5
4th Grade	Test 2	322.61	2.9482	24.842	43199.0
N=71	Test 3	323.93	3.0606	25.789	46554.6
Group A	Test 1	331.77	3.3794	26.176	40426.7
5th Grade	Test 2	329.65	3.4324	26.587	41705.7
N=60	Test 3	331.57	3.4194	26.487	41390.7
Group A	Test 1	343.13	2.9145	27.496	66528.4
6th Grade	Test 2	347.93	3.2126	30.307	80831.6
N=89	Test 3	343.79	3.2794	30.938	84230.9
Group A	Test 1	331.42	1.8734	27.788	169101.5
all grades	Test 2	334.77	2.0027	29.704	193234.6
N=220	Test 3	334.05	1.9767	29.319	188255.5
Group B	Test 1	317.63	2.8289	23.328	36459.8
4th Grade	Test 2	324.02	3.2581	26.867	48363.9
N=68	Test 3	328.59	3.0751	25.358	43082.5
Group B	Test 1	329.73	2.5464	22.918	42018.0
5th Grade	Test 2	331.88	2.9652	26.686	56972.8
N=81	Test 3	343.20	2.9430	26.487	56122.8
Group B	Test 1	336.65	3.0350	27.483	61180.7
6th Grade	Test 2	342.29	3.2798	29.700	71449.0
N=82	Test 3	345.62	3.4971	31.667	81227.3
Group B	Test 1	328.62	1.6984	25.813	153250.2
all grades	Test 2	333.26	1.8828	28.698	189424.9
N=231	Test 3	339.76	1.9044	28.945	192694.4

Group A - no films, no treatment
Group B - films only

TABLE II (continued)

Group	Test	Means	Standard Error of the Mean	Standard Deviation	Sum of Squares
Group C	Test 1	320.12	2.3351	18.826	22683.0
4th Grade	Test 2	334.66	2.8956	23.345	34878.6
N=65	Test 3	337.91	3.0831	24.857	39543.4
Group C	Test 1	326.82	2.6583	23.175	40279.4
5th Grade	Test 2	332.34	2.6757	23.326	40809.1
N=76	Test 3	339.47	2.8358	24.722	45838.9
Group C	Test 1	335.46	3.0285	25.156	43033.2
6th Grade	Test 2	344.41	3.3234	27.606	51822.6
N=69	Test 3	346.94	3.4294	28.487	55181.8
Group C	Test 1	327.59	1.6112	23.349	113943.0
all grades	Test 2	337.02	1.7427	25.255	133298.9
N=210	Test 3	341.44	1.8098	26.227	143757.8
Group D	Test 1	317.04	2.5486	21.775	34138.9
4th Grade	Test 2	329.08	2.9865	25.517	46879.5
N=73	Test 3	326.56	3.4686	29.635	63234.0
Group D	Test 1	321.61	3.4079	26.617	42506.6
5th Grade	Test 2	334.34	3.4942	27.290	44685.8
N=61	Test 3	340.54	3.2205	25.153	37961.1
Group D	Test 1	336.43	2.9667	27.191	61364.6
6th Grade	Test 2	343.26	2.8763	26.361	57678.2
N=84	Test 3	344.43	2.7937	25.604	54414.6
Group D	Test 1	325.79	1.8053	26.655	154172.3
all grades	Test 2	336.02	1.8237	26.927	157333.9
N=218	Test 3	337.36	1.8897	27.902	168936.1

Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator

TABLE II (continued)

Group	Test	Means	Standard Error of the Mean	Standard Deviation	Sum of Squares
Group E	Test 1	328.29	2.3386	22.309	44792.6
4th Grade	Test 2	336.21	2.5369	24.201	52711.0
N=91	Test 3	338.33	2.8414	27.106	66124.1
Group E	Test 1	337.33	2.7068	25.102	53558.9
5th Grade	Test 2	346.84	2.7122	25.152	53771.7
N=86	Test 3	347.56	2.9019	26.911	61559.2
Group E	Test 1	346.18	2.0068	18.283	27410.3
6th Grade	Test 2	343.48	2.6395	24.047	47418.7
N=83	Test 3	348.17	2.6337	23.994	47207.6
Group E	Test 1	336.45	1.3861	23.111	147952.8
all grades	Test 2	342.38	1.4477	24.139	161401.6
N=260	Test 3	344.62	1.5476	25.804	184435.6
Group F	Test 1	320.82	3.2094	24.017	31724.2
4th Grade	Test 2	329.71	3.3890	25.361	35375.4
N=56	Test 3	331.09	3.7590	28.130	43520.6
Group F	Test 1	322.89	2.9020	27.985	72052.9
5th Grade	Test 2	331.91	3.1014	29.908	82295.3
N=93	Test 3	334.54	3.4270	33.049	100483.1
Group F	Test 1	330.78	3.2657	25.296	37752.2
6th Grade	Test 2	332.88	3.5117	27.202	43656.2
N=60	Test 3	333.40	3.8367	29.719	52110.4
Group F	Test 1	324.60	1.8257	26.393	67842.0
all grades	Test 2	331.60	1.9282	27.876	69305.0
N=209	Test 3	333.29	2.1262	30.739	69657.0

Group E - films plus classroom discussion led by classroom teacher

Group F - no films

Other, more difficult to compute, statistical information was obtained by making use of the computers at The Pennsylvania State University Computation Center. The specific programs used for analysis will be described at the time that each is introduced.

Test of Hypotheses

Major Hypothesis. There will be no significant change in the attitudes toward science, scientists and scientific careers of the fourth-, fifth-, and sixth-grade students in the experimental groups or the control group, as measured by the Allison adaptation of the "Allen Attitude Scale."

The investigator calculated the tests of significant differences between pre-test and post-test, pre-test and retention-test, and post-test and retention-test by dividing the mean of the differences between the test scores by the standard error of the mean of these differences $t = \left(\frac{M_D}{\sigma_{M_D}} \right)$ as described in *Fundamental Statistics in Psychology and Education*.[1] The mean of the differences and standard error of the mean of these differences listed in Table III on pages 61 through 64 and used in this calculation were products of the Statistical Summary computer program used in the preliminary analysis. A tabulation of the results of the tests of significance of the mean of the differences is also in Table III, pages 61 through 64.

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[1] J. P. Guilford, *Fundamental Statistics in Psychology and Education* (New York: McGraw-Hill Book Company, 1965), p. 181.

TABLE III

SUMMARY OF EXPERIMENTAL DATA FOR ALLISON ADAPTATION OF "ALIEN ATTITUDE SCALE" FOR ALL EXPERIMENTAL SAMPLE GROUPS

Group	Tests***	Mean of the Differences	Standard Error of the Mean	Standard Deviation	Sum of Squares	t-Test
Group A	2-1	6.1690	2.8081	23.661	39190.0	2.197*
4th grade	3-1	7.4930	2.2212	18.716	24519.7	3.373**
N=71	3-2	1.3239	2.4642	20.764	30179.5	0.537
Group A	2-1	-2.1167	3.0926	23.955	33856.1	-0.684
5th grade	3-1	-0.2000	2.8333	21.947	28417.6	-0.071
N=60	3-2	1.9167	2.3389	18.117	19364.6	0.819
Group A	2-1	4.7978	2.5299	23.867	50126.4	1.896
6th grade	3-1	0.6517	2.4643	23.248	47562.2	0.264
N=89	3-2	-4.1461	1.7055	16.090	22781.1	-2.431*
Group A	2-1	3.3546	1.6153	23.959	125716.3	2.077*
all grades	3-1	2.6273	1.4622	21.688	103007.4	1.797
N=220	3-2	-0.7273	1.2400	18.392	74083.6	-0.586

Group A - no films, no treatment

* = P .05
** = P .01
*** = 1. Pre-Test
2. Post-Test
3. Retention-Test

TABLE III (continued)

Group	Tests	Mean of the Differences	Standard Error of the Mean	Standard Deviation	Sum of Squares	t-Test
Group B	2-1	6.3971	2.6546	21.891	32106.3	2.410*
4th grade	3-1	10.9559	2.8299	23.336	36486.9	3.871**
N=68	3-2	4.5588	2.3148	19.088	24412.8	1.969*
Group B	2-1	2.1482	2.6105	23.495	44160.2	0.823
5th grade	3-1	13.4691	2.5930	23.337	43570.2	5.194**
N=81	3-2	11.3210	2.4509	22.058	38923.7	4.619**
Group B	2-1	5.6463	2.7363	24.778	49730.7	2.063*
6th grade	3-1	8.9756	3.1214	28.265	64714.0	2.876**
N=82	3-2	3.3293	2.7782	25.157	51264.1	1.198
Group B	2-1	4.6407	1.5448	23.479	126793.2	3.004**
all grades	3-1	11.1342	1.6554	25.160	145596.8	6.726**
N=231	3-2	6.4935	1.4875	22.609	117563.7	3.155**
Group C	2-1	14.5383	2.6690	21.518	29634.2	5.447**
4th Grade	3-1	17.7846	2.7488	22.162	31433.0	6.470**
N=65	3-2	3.2461	2.6236	21.152	28634.1	1.237
Group C	2-1	5.5263	2.1784	18.991	27049.0	2.537*
5th grade	3-1	12.6579	2.1851	19.049	27215.1	5.793**
N=76	3-2	7.1316	1.9788	17.251	22318.7	3.604**
Group C	2-1	8.9420	2.4810	20.608	28879.8	3.604**
6th grade	3-1	11.4783	2.9509	24.512	40857.2	3.890**
N=69	3-2	2.5362	2.2795	18.935	24379.2	1.113

Group B - films only
Group C - films plus multiple-choice questions

TABLE III (continued)

Group	Tests	Mean of the Differences	Standard Error of the Mean	Standard Deviation	Sum of Squares	t-Test
Group C all grades N=210	2-1	9.4381	1.4195	20.570	88443.7	6.649**
	3-1	13.8571	1.5170	21.984	101007.7	9.134**
	3-2	4.4191	1.3179	19.097	76225.1	3.353**
Group D 4th grade N=73	2-1	12.0411	2.8432	24.292	42486.9	4.235**
	3-1	9.5206	3.1285	26.730	51442.2	3.043**
	3-2	-2.5205	2.4425	20.869	31356.2	-1.032
Group D 5th grade N=61	2-1	12.7377	2.9831	23.299	32569.8	4.270**
	3-1	18.9344	3.5208	27.498	45369.7	5.378**
	3-2	6.1967	2.9952	23.394	32835.6	2.069*
Group D 6th grade N=84	2-1	6.8333	2.5268	23.159	44515.7	2.704**
	3-1	8.0000	2.6472	24.262	48856.0	3.022**
	3-2	1.1667	2.1794	19.975	33115.7	0.535
Group D all grades N=218	2-1	10.2294	1.6004	23.630	121164.5	6.392**
	3-1	11.5688	1.7828	26.322	150353.5	6.489**
	3-2	1.3395	1.4527	21.449	99836.9	0.922
Group E 4th grade N=91	2-1	7.9231	2.4201	23.086	47966.5	3.274**
	3-1	10.0440	2.6540	25.318	57687.8	3.784**
	3-2	2.1209	2.0243	19.310	33559.7	1.048
Group E 5th grade N=86	2-1	9.5116	2.2364	20.740	36561.5	4.253**
	3-1	10.2326	2.2827	21.169	38091.3	4.483**
	3-2	0.7209	1.6481	15.284	19855.3	0.437

Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher

TABLE III (continued)

Group	Tests	Mean of the Differences	Standard Error of the Mean	Standard Deviation	Sum of Squares	t-Test
Group E 6th grade N=83	2-1	-2.6988	2.3382	21.302	37209.5	-1.154
	3-1	1.9880	2.3776	21.661	38475.0	0.836
	3-2	4.6868	1.9572	17.831	26071.9	2.395*
Group E all grades N=260	2-1	5.9317	1.3327	22.221	136773.7	4.451**
	3-1	8.1691	1.3786	22.986	146351.1	5.926**
	3-2	2.2374	1.0398	[illegible]7.337	83262.3	2.152*
Group F 4th grade N=56	2-1	8.8929	3.3134	24.795	33813.4	2.684**
	3-1	10.2679	2.9603	22.153	26991.0	3.469**
	3-2	1.3750	2.2670	16.965	15829.1	0.607
Group F 5th grade N=93	2-1	9.0215	2.3227	22.399	46158.0	3.884**
	3-1	11.6452	2.7723	26.735	65757.3	4.201**
	3-2	2.6234	1.9174	18.490	31453.8	1.368
Group F 6th grade N=60	2-1	2.1000	2.5573	19.809	23151.4	0.821
	3-1	2.6167	3.0768	23.833	33512.2	0.850
	3-2	0.5167	2.7571	21.356	26909.0	0.187
Group F all grades N=209	2-1	7.0000	1.5552	22.483	105144.0	4.501**
	3-1	8.6842	1.7255	24.945	129425.2	5.033**
	3-2	1.6842	1.3079	18.908	74361.2	1.288

Group F - no films

A null hypothesis has been stated above. The testing of the hypothesis was completed and results obtained are included in Table III. Statements concerning the possible rejection of the null hypothesis using 1.96 sigmas or 2.58 sigmas to indicate the probabilities of .05 or .01, respectively, that a change in score could occur by chance alone follow:

1. It is possible to reject the null hypothesis of the following groups at the 1% level of significance. It seems that the attitudes toward science, scientists, and scientific careers of these students have undergone a very significant change between the tests indicated.

Pre-Post Tests

4th grade	Groups C, D, E, F
5th grade	Groups D, E, F
6th grade	Groups C, D
all grades	Groups B, C, D, E, F

Pre-Retention Tests

4th grade	Groups A, B, C, D, E, F
5th grade	Groups B, C, D, E, F
6th grade	Groups B, C, D
all grades	Groups B, C, D, E, F

Post-Retention Tests

5th grade	Groups B, C
all grades	Groups B, C

Group A - no films, no treatment
Group B - films only
Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher
Group F - no films

2. It is possible to reject the null hypothesis of the following groups at the 5% level of significance. It seems that the attitudes toward science, scientists, and scientific careers of these students have undergone a significant change between the tests indicated.

Pre-Post Tests

4th grade	Groups A, B
5th grade	Group C
6th grade	Group B
all grades	Group A

Pre-Retention Tests

No groups

Post-Retention Tests

4th grade	Group B
5th grade	Group D
6th grade	Groups A, E
all grades	Group E

Group A - no films, no treatment
Group B - films only
Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher
Group F - no films

3. It is impossible to reject the null hypothesis of the following groups at the 5% level. It seems that the difference between the means cannot be considered a significant change in the attitudes toward science, scientists and scientific careers of these students.

Pre-Post Tests

5th grade	Groups A, B
6th grade	Groups A, E, F

Pre-Retention Tests

5th grade	Group A
6th grade	Groups A, E, F
all grades	Group A

Post-Retention Tests

4th grade	Groups A, C, D, E, F
5th grade	Groups A, E, F
6th grade	Groups B, C, D, F
all grades	Groups A, D, F

Group A - no films, no treatment
Group B - films only
Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher
Group F - no films

Sub-Problem 1. Are changes in attitude toward science, scientists, and scientific careers related to the treatment given the experimental groups?

In order to determine the answer to the above sub-problem, it must be stated as a null hypothesis to be tested. This re-statement follows:

There will be no significant difference in the change in attitudes of the students toward science, scientists, and scientific careers related to the treatment given to each group.

The mean of the differences between pre-test and post-test as given in Table III on pages 61 through 64 for each group were tested with $t = \dfrac{M_1 - M_2}{\sqrt{\left(\dfrac{\Sigma x_1^2 + \Sigma x_2^2}{N_1 + N_2 - 2}\right)\left(\dfrac{N_1 + N_2}{N_1\,N_2}\right)}}$. The results of these calculations are listed in Table IV on the top half of page 69.

The mean of the differences between pre-test and retention-test were tested in similar fashion. The results of this calculation are listed in Table V on the bottom half of page 69.

It is possible to reject the null hypothesis at the 1% level of significance. It seems that the attitude changes of Group C (films plus multiple-choice questions) or Group D (films plus large group discussion led by the investigator) were very significantly different from the change in attitude toward science, scientists, and scientific careers of Group A (no films, no treatment) between the pre-test and the post-test.

It is possible to reject the null hypothesis between the 5% and 1% level of significance for the following additional groups. The mean change in attitude toward science, scientists, and scientific careers during the period of time between pre-test and post-test was greater for Group C (films plus multiple-choice questions) or Group D (films plus large group discussion led by the investigator) than for Group B (films only). It was also greater for Group D (films plus large group discussion led by the investigator) than for Group E (films plus classroom discussion led by the classroom teacher) at a level of significance between 5% and 1%.

A null hypothesis for the mean differences between the pre-test and the retention-test could be stated:

There will be no significant difference in the attitudes of the students toward science, scientists, and scientific careers

TABLE IV

MATRIX OF t-TESTS FOR DIFFERENCES IN CHANGE OF ATTITUDE BETWEEN THE PRE-TEST AND THE POST-TEST AS MEASURED BY THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE"

	Group B	Group C	Group D	Group E	Group F
Group A	0.603	2.819**	3.023**	1.266	1.623
Group B		2.273*	2.513*	0.636	1.074
Group C			0.369	1.782	1.158
Group D				2.079*	1.446
Group E					0.523

TABLE V

MATRIX OF t-TESTS FOR DIFFERENCES IN CHANGE OF ATTITUDE BETWEEN THE PRE-TEST AND THE RETENTION-TEST AS MEASURED BY THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE"

	Group B	Group C	Group D	Group E	Group F
Group A	3.838**	5.332**	3.882**	2.739**	2.688**
Group B		1.205	0.179	1.388	1.024
Group C			0.974	2.758**	2.252*
Group D				1.533	1.161
Group E					0.236

* = P .05
** = P .01

Group A - no films, no treatment (N=220)
Group B - films only (N=231)
Group C - films plus multiple-choice questions (N=210)
Group D - films plus large group discussion led by the investigator (N=218)
Group E - films plus classroom discussion led by classroom teacher (N=260)
Group F - no films (N=209)

related to the treatment given to each group.

It is possible to reject the null hypothesis at the 5% and 1% level of significance. It seems that the attitude changes between pre-test and retention-test of Group B, Group C, Group D, Group E, and Group F, as listed in Table V on page 69 were very significantly different from the changes in attitude toward science, scientists, and scientific careers of Group A (no films, no treatment). The change in attitude toward science, scientists, and scientific careers for Group C (films plus multiple-choice questions) was also very significantly greater than the change for Group E (films plus classroom discussion led by classroom teacher) beyond the 1% level of significance.

In addition to the above, it is possible to reject the null hypothesis at the 5% level of significance. It seems that the attitude change between pre-test and retention-test of Group C (films plus multiple-choice questions) was significantly greater than the change for Group F (no films) beyond the 5% level of significance.

Sub-Problem 2. Are changes in attitude toward science, scientists, and scientific careers related to the grade level (fourth, fifth, sixth) of the student?

This sub-problem must be restated as a null hypothesis to be tested. The restatement follows:

There will be no significant difference in the change in attitude toward science, scientists, and scientific careers of the students within each treatment group related to the grade level (fourth, fifth, or sixth) to which they were assigned.

The formula used for the test of the null hypothesis above was the t-test formula included on page 67. Using the information from Table III, pages 61 through 64 a t-test was calculated between the mean of the differences for fourth and fifth grades, fourth and sixth grades, and fifth and sixth grades within each of the groups of the study. The results of the t-test are listed in Table VI and Table VII on page 72.

It is possible to reject the null hypothesis at the 1% level of significance for the post-test minus pre-test change for Group C (films plus multiple-choice questions) and Group E (films plus classroom discussion led by classroom teacher). The mean of the difference between pre-test and post-test for: Group C (films plus multiple-choice questions) 4th grade is greater than Group C 5th grade, Group E (films plus classroom discussion led by classroom teacher) 4th grade is greater than Group E 6th grade, and Group E (films plus classroom discussion led by classroom teacher) 5th grade is greater than Group E 6th grade. This is a very significant difference between these means beyond the 1% level.

It is further possible to reject the null hypothesis at the 5% level of significance with the groups mentioned in the preceding paragraph and one additional group for the post-test minus pre-test change. It seems that the mean of the difference between post-test and pre-test for Group A (no films, no treatment) 4th grade is greater than Group A 5th grade at or beyond the 5% level of significance.

TABLE VI

TABLE OF t-TESTS FOR DIFFERENCES IN CHANGE OF ATTITUDE BETWEEN PRE-TEST AND POST-TEST AS MEASURED BY THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE" AMONG THE FOURTH, FIFTH, AND SIXTH GRADES WITHIN EACH TREATMENT GROUP TO DETERMINE IF A PARTICULAR TREATMENT IS MORE EFFECTIVE AT ONE GRADE LEVEL THAN AT ANOTHER GRADE LEVEL

Grade Levels	Group A	Group B	Group C	Group D	Group E	Group F
4-5	1.986*	1.134	2.641**	0.162	0.481	0.033
4-6	0.362	0.195	1.538	1.374	3.144**	1.636
5-6	1.732	0.925	1.039	1.462	3.776**	1.951

TABLE VII

TABLE OF t-TESTS FOR DIFFERENCES IN CHANGE OF ATTITUDE BETWEEN PRE-TEST AND RETENTION-TEST AS MEASURED BY THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE" AMONG THE FOURTH, FIFTH, AND SIXTH GRADES WITHIN EACH TREATMENT GROUP TO DETERMINE IF A PARTICULAR TREATMENT IS MORE EFFECTIVE AT ONE GRADE LEVEL THAN AT ANOTHER GRADE LEVEL

Grade Levels	Group A	Group B	Group C	Group D	Group E	Group F
4-5	2.166*	0.655	1.478	1.990*	0.054	0.324
4-6	2.013*	0.462	1.559	0.374	2.245*	1.787
5-6	0.224	1.106	0.325	2.532*	2.502*	2.126*

* = P .05
** = P .01

Group A - no films, no treatment (N=220)
Group B - films only (N= 231)
Group C - films plus multiple-choice questions (N=210)
Group D - films plus large group discussion led by the investigator (N=218)
Group E - films plus classroom discussion led by classroom teacher (N=260)
Group F - no films (N=209)

It is possible to reject the null hypothesis at the 5% level of significance for the retention-test minus pre-test change in attitude toward science, scientists, and scientific careers. It seems that the mean of the difference between the pre-test and the retention-test shows that Group A (no films, no treatment) 4th grade is greater than Group A 5th grade, Group A (no films, no treatment) 4th grade is greater than Group A 6th grade, Group D (films plus large group discussion led by the investigator) 5th grade is greater than Group D 4th grade, Group D (films plus large group discussion led by the investigator) 5th grade is greater than Group D 6th grade, Group E (films plus classroom discussion led by classroom teacher) 4th grade is greater than Group E 6th grade, Group E (films plus classroom discussion led by classroom teacher) 5th grade is greater than Group E 6th grade, and Group F (no films) 5th grade is greater than Group F 6th grade at or beyond the 5% level of significance.

Another method of showing the relationship of the grade (fourth, fifth, sixth) placement of the student to the change in attitude toward science, scientists, and scientific careers is a coefficient of correlation. Guilford says:

> A coefficient of correlation is a single number that tells us to what extent two things are related, to what extent variations in the one go with variations in the other.[2]

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[2] J. P. Guilford, Fundamental Statistics in Psychology and Education (New York: McGraw-Hill Book Company, 1965), p. 91.

A program to calculate Phi, Point Biserial, and Product Moment Coefficients of Correlations was made available by William Verity of the Computation Center Staff at The Pennsylvania State University and was used there to compute the coefficients of correlation listed in Tables VIII, IX, X, XI, XII and XIII on pages 75 through 85.

These tables will be referred to in this sub-problem and the sub-problems to follow.

A null hypothesis for sub-problem 2 using these data would read:

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the grade level (fourth, fifth, sixth) to which they were assigned.

It is impossible to reject this null hypothesis at the 5% level of significance for any of the groups listed on Tables VIII, IX, X, XI, XII and XIII on pages 75, 77, 79, 81, 83, and 85. Evidently the relationship between the attitude change toward science, scientists, and scientific careers and the grade to which the student is assigned cannot be considered a significant one.

Sub-Problem 3. Are changes in attitude toward science, scientists, and scientific careers related to the student's mental age as measured by "The Lorge-Thorndike Intelligence Tests"?[3]

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[3] Irving Lorge and Robert L. Thorndike, "The Lorge-Thorndike Intelligence Tests" (Boston, Massachusetts: Houghton Mifflin Co., 1957).

TABLE VIII

A MATRIX OF r s FOR GROUP A AMONG ATTITUDE SCORES AS MEASURED BY ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE," CHANGE OF ATTITUDE, AND EIGHT FACTORS UNDER INVESTIGATION

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Sex	-0.198**	-0.196**	-0.177*	-0.014	0.013	0.034
Plan to Elect Science as a Career Field	0.146	0.128	0.173*	-0.011	0.047	0.069
Science Training of Parents	-0.013	-0.024	-0.065	-0.015	-0.072	-0.065
Grade Placement of Student	0.407**	0.368**	0.290**	-0.016	-0.129	-0.131
Economic Status of Parents	0.053	0.047	-0.006	-0.003	-0.076	-0.085
Science Achievement Score	0.590**	0.569**	0.596**	0.022	0.050	0.031
Mean of Achievement Scores	0.636**	0.617**	0.612**	0.027	0.012	-0.021
I. Q.	0.380**	0.440**	0.492**	0.015	0.178*	0.073
Pre-Test		0.654**	0.713**	-0.348**	-0.318**	0.079

TABLE VIII (continued)

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Post-Test			0.806**	0.481**	0.251**	-0.330**
Retention-Test				0.172**	0.439**	0.293**
Post-Test Pre-Test Difference					0.679**	-0.501**
Retention-Test Pre-Test Difference						0.294

* = P .05
** = P .01
Group A - no films, no treatment

TABLE IX

A MATRIX OF r s FOR GROUP B AMONG ATTITUDE SCORES AS MEASURED BY ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE, CHANGE OF ATTITUDE, AND EIGHT FACTORS UNDER INVESTIGATION

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Sex	-0.021	-0.093	0.049	-0.091	0.078	0.181**
Plan to Elect Science as a Career Field	0.120	0.187**	0.224**	0.096	0.135	0.050
Science Training of Parents	-0.030	-0.068	-0.083	-0.050	-0.064	-0.019
Grade Placement of Student	0.294**	0.257**	0.231**	-0.009	-0.035	-0.031
Economic Status of Parents	0.155*	0.074	0.049	-0.080	-0.103	-0.031
Science Achievement Score	0.520**	0.449**	0.487**	-0.023	0.026	0.053
Mean of Achievement Scores	0.563**	0.523**	0.501**	0.020	-0.002	-0.022
I. Q.	0.245**	0.277**	0.223**	0.069	0.005	-0.066
Pre-Test		0.634**	0.583**	-0.325**	-0.355**	-0.058

TABLE IX (continued)

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Post-Test			0.692**	0.526**	0.147*	-0.383**
Retention-Test				0.205**	0.552**	0.401**
Post-Test Pre-Test Difference					0.570**	-0.404**
Retention-Test Pre-Test Difference						0.521**

* = P .05
** = P .01
Group B - films only

TABLE X

A MATRIX OF r s FOR GROUP C AMONG ATTITUDE SCORES AS MEASURED BY ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE," CHANGE OF ATTITUDE, AND EIGHT FACTORS UNDER INVESTIGATION

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Sex	-0.100	-0.017	-0.065	0.093	0.029	-0.067
Plan to Elect Science as a Career Field	0.239**	0.312**	0.332**	0.111	0.142*	0.043
Science Training of Parents	0.023	0.138	0.120	0.143*	0.118	-0.017
Grade Placement of Student	0.263**	0.157*	0.139*	-0.106	-0.114	-0.017
Economic Status of Parents	-0.024	0.016	-0.003	0.047	0.022	-0.025
Science Achievement Score	0.378**	0.417**	0.372**	0.082	0.042	-0.040
Mean of Achievement Scores	0.502**	0.477**	0.411**	0.016	-0.043	-0.068
I. Q.	0.394**	0.351**	0.385**	-0.015	0.041	0.064
Pre-Test		0.644**	0.612**	-0.344**	-0.332**	-0.011

TABLE X (continued)

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Post-Test			0.725**	0.496**	0.181**	-0.326**
Retention-Test				0.196**	0.543**	0.414**
Post-Test Pre-Test Difference					0.599**	-0.388**
Retention-Test Pre-Test Difference						0.506**

* = P .05
** = P .01
Group C - films plus multiple-choice questions

TABLE XI

A MATRIX OF r s FOR GROUP D AMONG ATTITUDE SCORES AS MEASURED BY ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE," CHANGE OF ATTITUDE, AND EIGHT FACTORS UNDER INVESTIGATION

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Sex	-0.118	-0.121	-0.120	-0.005	-0.008	-0.004
Plan to Elect Science as a Career Field	0.043	0.066	0.097	0.026	0.059	0.043
Science Training of Parents	0.047	0.162*	0.101	0.131	0.059	-0.071
Grade Placement of Student	0.312**	0.225**	0.269 **	-0.096	-0.031	0.068
Economic Status of Parents	0.071	0.118	0.081	0.054	0.014	-0.043
Science Achievement Score	0.431**	0.406**	0.452**	-0.023	0.043	0.079
Mean of Achievement Scores	0.556**	0.501**	0.527**	-0.056	-0.004	0.057
I. Q.	0.331**	0.363**	0.359**	0.040	0.045	0.011
Pre-Test		0.611**	0.535**	-0.432**	-0.445**	-0.071

TABLE XI (continued)

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Post-Test			0.694**	0.450**	0.117	-0.352**
Retention-Test				0.188**	0.518**	0.429**
Post-Test Pre-Test Difference					0.636**	-0.321**
Retention-Test Pre-Test Difference						0.527**

* = P .05
** = P .01
Group D - films plus large group discussion led by the investigator

TABLE XII

A MATRIX OF r s FOR GROUP E AMONG ATTITUDE SCORES AS MEASURED BY ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE," CHANGE OF ATTITUDE, AND EIGHT FACTORS UNDER INVESTIGATION

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Sex	0.009	0.021	0.034	0.014	0.029	0.020
Plan to Elect Science as a Career Field	0.091	0.075	0.122	-0.013	0.045	0.077
Science Training of Parents	0.050	0.086	0.058	0.041	0.015	-0.033
Grade Placement of Student	0.212**	0.132	0.137	-0.077	-0.059	0.020
Economic Status of Parents	0.154**	0.112	0.138*	-0.038	0.000	0.050
Science Achievement Score	0.559**	0.562**	0.531**	0.028	0.034	0.009
Mean of Achievement Scores	0.622**	0.610**	0.566**	0.016	0.009	-0.008
I. Q.	0.393**	0.453**	0.408**	0.083	0.063	-0.023
Pre-Test		0.558**	0.563**	-0.433**	-0.373**	0.061

TABLE XII (continued)

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Post-Test			0.761**	0.506**	0.293**	-0.260**
Retention-Test				0.241**	0.556**	0.429**
Post-Test Pre-Test Difference					0.706**	-0.345**
Retention-Test Pre-Test Difference						0.421**

* = P .05
** = P .01
Group E - films plus classroom discussion led by classroom teacher

TABLE XIII

A MATRIX OF r s FOR GROUP F AMONG ATTITUDE SCORES AS MEASURED BY ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE," CHANGE OF ATTITUDE, AND EIGHT FACTORS UNDER INVESTIGATION

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Sex	-0.092	-0.131	-0.083	-0.054	-0.004	0.058
Plan to Elect Science as a Career Field	0.180*	0.281**	0.239**	0.137	0.104	-0.025
Science Training of Parents	0.240**	0.170*	0.153*	-0.071	-0.065	-0.001
Grade Placement of Student	0.142*	0.042	0.027	-0.115	-0.117	-0.018
Economic Status of Parents	0.164*	0.198**	0.156*	0.053	0.018	-0.039
Science Achievement Score	0.566**	0.499**	0.505**	-0.046	0.023	0.085
Mean of Achievement Scores	0.570**	0.535**	0.523**	-0.006	0.042	0.062
I. Q.	0.505**	0.537**	0.492**	0.073	0.072	0.008
Pre-Test		0.658**	0.628**	-0.358**	-0.284**	0.051

TABLE XIII (continued)

	Pre-Test	Post-Test	Retention-Test	Post-Test Pre-Test Difference	Retention-Test Pre-Test Difference	Retention-Test Post-Test Difference
Post-Test			0.796**	0.467**	0.285**	-0.180*
Retention-Test				0.250**	0.568**	0.452**
Post-Test Pre-Test Difference					0.687**	-0.283**
Retention-Test Pre-Test Difference						0.503**

* = P .05
** = P .01
Group F - no films

It is necessary to restate the above in the form of a null hypothesis to be tested.

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the student's mental age as measured by "The Lorge-Thorndike Intelligence Tests."

It is possible to reject the null hypothesis at the 5% level of significance for Group A (no films, no treatment) as indicated in Table VIII on page 75. It seems that a relationship does exist in this group between the attitude change toward science, scientists, and scientific careers and the student's mental age.

It is impossible to reject the null hypothesis at the 5% level of significance for Group B, Group C, Group D, Group E, or Group F. It seems possible that the correlation could indeed be zero between the attitude change toward science, scientists, and scientific careers and the student's mental age for these groups.

Sub-Problem 4. Are changes in attitude toward science, scientists, and scientific careers related to the mean of the achievement scores as measured by the "Stanford Achievement Test"?[4]

It is necessary to restate the above in the form of a null hypothesis to be tested.

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[4] Truman L. Kelley, Richard Madden, Eric F. Gardner, and Herbert C. Reedman, "Stanford Achievement Test" (New York: Harcourt, Brace, and World, Inc., 1964).

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the mean of the achievement scores as measured by the "Stanford Achievement Test."

It is impossible to reject the null hypothesis at the 5% level of significance for any of the groups. It seems possible that the correlation could indeed be zero between the attitude change toward science, scientists, and scientific careers and the mean of the achievement scores.

Sub-Problem 5. Are changes in attitude toward science, scientists, and scientific careers related to the science achievement score as measured by the "Stanford Achievement Test"?

It is necessary to restate the above in the form of a null hypothesis to be tested.

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the science achievement score as measured by the "Stanford Achievement Test."

It is impossible to reject the null hypothesis at the 5% level of significance for any of the groups. It seems possible that the correlation could indeed be zero between the attitude change toward science, scientists, and scientific careers and the science achievement score.

Sub-Problem 6. Are changes in attitude toward science, scientists, and scientific careers related to the sex of the student?

It is necessary to restate the above in the form of a null hypothesis to be tested.

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the sex of the student.

It is possible to reject the null hypothesis at the 1% level of significance for Group B (films only) as indicated in Table VIII on page 75. It seems that a relationship does exist in this group between the attitude change toward science, scientists, and scientific careers, which took place during the period of time after the post-test and before the retention-test, and the sex of the students. These results indicate that the change in attitude toward science, scientists, and scientific careers for boys was greater than the change in attitude toward science, scientists, and scientific careers for girls during this period of time for this treatment group.

It is impossible to reject the null hypothesis at the 5% level of significance for Group A, Group C, Group D, Group E, and Group F. For these groups, it seems possible that the correlation could indeed be zero between the attitude change toward science, scientists, and scientific careers and the sex of the student.

Sub-Problem 7. Are changes in attitude toward science, scientists, and scientific careers related to the student's plans to elect science?

It is necessary to restate the above in the form of a null hypothesis to be tested.

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the student's plans to elect science.

It is possible to reject the null hypothesis at the 5% level of significance for Group C (films plus multiple-choice questions) as indicated in Table X on page 79. It seems that a relationship does exist in this group between the attitude change toward science, scientists, and scientific careers and the student's plans to elect science over the period of time between the pre-test and the retention-test. These results indicate that those students who plan to elect science as their career choice had the greatest change in attitude toward science, scientists, and scientific careers over the period of time between the pre-test and the retention-test in this treatment group.

It is impossible to reject the null hypothesis at the 5% level of significance for Group A, Group B, Group D, Group E, and Group F. It would seem that the correlation between the change in attitude toward science, scientists, and scientific careers and the student's plans to elect science could be zero for these groups.

Sub-Problem 8. Are changes in attitude toward science, scientists, and scientific careers related to science training of parents as recorded on the student's permanent record card?

It is necessary to restate the above as a null hypothesis to be tested.

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the science training of parents as recorded on the student's permanent record card.

It is possible to reject the null hypothesis at the 5% level of significance for Group C (films plus multiple-choice questions) as indicated in Table X on page 79. It seems that a relationship does exist in this group between the attitude change toward science, scientists, and scientific careers and the science training of parents over the period of time between the pre-test and the post-test. These results indicate that the students whose parents were trained in some field of science had the greatest change in attitude toward science, scientists, and scientific careers over the period of time between the pre-test and the post-test in this treatment group.

It is impossible to reject the null hypothesis at the 5% level of significance for Group A, Group B, Group D, Group E, and Group F. It would seem that the correlation between change in attitude toward science, scientists, and scientific careers and the science training of parents could be zero, or some correlation near zero, for these groups.

Sub-Problem 9. Are changes in attitude toward science, scientists, and scientific careers related to the economic status of parents as determined by parents' job title as recorded on the student's permanent record card?

It is necessary to restate the above as a null hypothesis to be tested.

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the economic status of parents as determined by parents' job title recorded on the student's permanent record card.

It is impossible to reject the null hypothesis at the 5% level of significance for any of the treatment groups. It would seem that the correlation between change in attitude toward science, scientists, and scientific careers and the economic status of parents could be zero, or some correlation near zero for all these groups.

Summary

Major Hypothesis There will be no significant change in the attitude toward science, scientists, and scientific careers of the fourth-, fifth-, and sixth-grade students in the experimental groups or the control group, as measured by the Allison adaptation of the "Allen Attitude Scale."

The level of significance, with which the major hypothesis was rejected for each group or sub-group in the study, will be indicated in Table XIV on page 93 as ** (null hypothesis rejected at 1% level of significance), and * (null hypothesis rejected at 5% level of significance).

Sub-Problem 1. There will be no significant difference in the change in attitude toward science, scientists, and scientific careers of the students related to the treatment given to each group.

For the change in attitude toward science, scientists, and

TABLE XIV

A TABLE OF t-TESTS OF THE MEAN OF THE DIFFERENCES IN ATTITUDE AS MEASURED BY THE ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE" FOR EACH TREATMENT GROUP AND SUB-GROUP

Group	Grade	N	Pre-Test Post-Test Difference	Pre-Test Retention-Test Difference	Post-Test Retention-Test Difference
A	4	71	2.197*	3.373**	0.537
A	5	60	-0.684	-0.071	0.819
A	6	89	1.896	0.264	-2.431*
A	all	220	2.077*	1.797	-0.586
B	4	68	2.410*	3.871**	1.969*
B	5	81	0.823	5.194**	4.619**
B	6	82	2.063*	2.876**	1.198
B	all	231	3.004**	6.726**	3.155**
C	4	65	5.447**	6.470**	1.237
C	5	76	2.537*	5.793**	3.604**
C	6	69	3.604**	3.890**	1.113
C	all	210	6.649**	9.134**	3.353**
D	4	73	4.235**	3.043**	-1.032
D	5	61	4.270**	5.378**	2.069*
D	6	84	2.704**	3.022**	0.535
D	all	218	6.392**	6.489**	0.922
E	4	91	3.274**	3.784**	1.048
E	5	86	4.253**	4.483**	0.437
E	6	83	-1.154	0.836	2.395*
E	all	260	4.451**	5.926**	2.152*
F	4	56	2.684**	3.469**	0.607

TABLE XIV (continued)

Group	Grade	N	Pre-Test Post-Test Difference	Pre-Test Retention-Test Difference	Post-Test Retention-Test Difference
F	5	93	3.884**	4.201**	1.368
F	6	60	0.821	0.850	0.187
F	all	209	4.501**	5.033**	1.288

*P .05
**P .01
Group A - no films, no treatment
Group B - films only
Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher
Group F - no films

scientific careers indicated by the pre-test and post-test difference:

Group C had a greater change than Group A beyond the 1% level;

Group D had a greater change than Group A beyond the 1% level;

Group C had a greater change than Group B beyond the 5% level;

Group D had a greater change than Group B beyond the 5% level;

Group D had a greater change than Group E beyond the 5% level.

For the change in attitude toward science, scientists, and scientific careers indicated by the pre-test retention-test difference:

Group B had a greater change than Group A beyond the 1% level;

Group C had a greater change than Group A beyond the 1% level;

Group D had a greater change than Group A beyond the 1% level;

Group E had a greater change than Group A beyond the 1% level;

Group F had a greater change than Group A beyond the 1% level;

Group C had a greater change than Group E beyond the 1% level;

Group C had a greater change than Group F beyond the 5% level.

Group A - no films, no treatment
Group B - films only
Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher
Group F - no films

Sub-Problem 2. There will be no significant difference in the change in attitude toward science, scientists, and scientific careers of the students within each treatment group related to the grade level (fourth, fifth, sixth) to which they were assigned.

For the change in attitude toward science, scientists, and scientific careers indicated by the pre-test post-test difference:

Group C 4th grade had a greater change than Group C 5th grade beyond the 1% level;

Group E 4th grade had a greater change than Group E 6th grade beyond the 1% level;

Group E 5th grade had a greater change than Group E 6th grade beyond the 1% level;

Group A 4th grade had a greater change than Group A 5th grade beyond the 5% level.

For the change in attitude toward science, scientists, and scientific careers indicated by the pre-test retention-test difference:

Group A 4th grade had a greater change than Group A 5th grade beyond the 5% level;

Group A 4th grade had a greater change than Group A 6th grade beyond the 5% level;

Group D 5th grade had a greater change than Group D 4th grade beyond the 5% level;

Group D 5th grade had a greater change than Group D 6th grade beyond the 5% level;

Group E 4th grade had a greater change than Group E 6th grade beyond the 5% level;

Group E 5th grade had a greater change than Group E 6th grade at the 5% level;

Group F 5th grade had a greater change than Group F 6th grade beyond the 5% level.

Group A - no films, no treatment
Group B - films only
Group C - films plus multiple-choice questions
Group D - films plus large group discussion led by the investigator
Group E - films plus classroom discussion led by classroom teacher
Group F - no films

This sub-problem was restated in the following null hypothesis:

There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the grade level (fourth, fifth, sixth) to which they were assigned.

It was impossible to reject this null hypothesis at either the 1% or 5% level of significance.

Sub-Problem 3. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the student's mental age as measured by "The Lorge-Thorndike Intelligence Tests."

It was possible to reject this null hypothesis at the 5% level of significance for Group A (no films, no treatment) only as indicated in Tables VIII, IX, X, XI, XII, and XIII on pages 75 through 85.

Sub-Problem 4. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the mean of the achievement scores as measured by the "Stanford Achievement Test."

It was impossible to reject this null hypothesis at either the

1% or 5% level of significance as indicated in Tables VIII, IX, X, XI, XII and XIII on pages 75 through 85.

Sub-Problem 5. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the science achievement score as measured by the "Stanford Achievement Test."

It was impossible to reject this null hypothesis at either the 1% or 5% level of significance as indicated in Tables VIII, IX, X, XI, XII and XIII , pages 75 through 85.

Sub-Problem 6. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the sex of the student.

It was possible to reject this null hypothesis at the 1% level of significance for the attitude change toward science, scientists, and scientific careers which took place between the post-test and the retention-test within Group B (films only) only as indicated in Tables VIII, IX, X, XI, XII and XIII on pages 75 through 85.

Sub-Problem 7. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the student's plans to elect science.

It was possible to reject this null hypothesis at the 5% level of significance for the attitude change toward science, scientists, and scientific careers which took place between the pre-test and the retention-test within Group C (films plus multiple-choice questions) only as indicated in Tables VIII, IX, X, XI, XII and XIII on pages 75 through 85.

Sub-Problem 8. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the science training of parents as recorded on the student's permanent record card.

It was possible to reject this null hypothesis at the 5% level of significance for the attitude change toward science, scientists, and scientific careers which took place between the pre-test and the post-test within Group C (films plus multiple-choice questions) only as indicated in Tables VIII, IX, X, XI, XII and XIII on pages 75 through 85.

Sub-Problem 9. There is no correlation between the change in attitude toward science, scientists, and scientific careers of the students within each treatment group and the economic status of parents as determined by parents' job title recorded on the student's permanent record card.

It was impossible to reject this null hypothesis at either the 1% or 5% level of significance as indicated in Tables VIII, IX, X, XI, XII, and XIII on pages 75 through 85.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Can the attitudes of a selected group of fourth-, fifth-, and sixth-grade students concerning science, scientists, and scientific careers be changed favorably as a result of the treatments applied to ten motivational films which were viewed one each week?

Sub-Problem 1. Are changes in attitude toward science, scientists, and scientific careers related to the treatment given the experimental groups?

Sub-Problem 2. Are changes in attitude toward science, scientists, and scientific careers related to the grade level (fourth, fifth, sixth) of the student?

Sub-Problem 3. Are changes in attitude toward science, scientists, and scientific careers related to the student's mental age as measured by "The Lorge-Thorndike Intelligence Tests"?[1]

Sub-Problem 4. Are changes in attitude toward science, scientists, and scientific careers related to the mean of the achievement scores as measured by the "Stanford Achievement Test"?[2]

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[1] Irving Lorge and Robert L. Thorndike, "The Lorge-Thorndike Intelligence Tests" (Boston, Massachusetts: Houghton Mifflin Co., 1957).

[2] Truman L. Kelley, Richard Madden, Eric F. Gardner, and Herbert C. Reedman, "Stanford Achievement Test" (New York: Harcourt, Brace, and World, Inc., 1964).

Sub-Problem 5. Are changes in attitude toward science, scientists, and scientific careers related to the science achivement scores as measured by the "Stanford Achievement Test"?[3]

Sub-Problem 6. Are changes in attitude toward science, scientists, and scientific careers related to the sex of the student?

Sub-Problem 7. Are changes in attitude toward science, scientists, and scientific careers related to the student's plans to elect science?

Sub-Problem 8. Are changes in attitude toward science, scientists, and scientific careers related to science training of parents as recorded on the student's permanent record card?

Sub-Problem 9. Are changes in attitude toward science, scientists, and scientific careers related to the economic status of parents as determined by parents' job title recorded on the student's permanent record card?

Procedure During the Experiment. Groups A, B, C, D, E, and F were pre-tested with the Allison adaptation of the "Alien Attitude Scale" in September, 1965.

Group A did not view the films.

Groups B, C, D, and E viewed one of the "Horizons of Science" film series each week for ten weeks beginning in September, 1965.

The students in Group B viewed the films only.

The students in Group C each received a series of multiple-choice questions to read prior to the time they viewed each of the ten films. After viewing each film they answered the questions, submitted their answers, and then their teachers went over each question indicating the correct choice. These students were permitted to keep the question sheets.

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[3] Ibid.

The students in Group D viewed each of the ten films and discussed each film immediately following the film showing. The investigator led the discussion with the entire experimental Group D present using the discussion materials found in Appendix B.

The students in Group E viewed each of the ten films and discussed each film immediately following the film showing. The classroom teachers led the discussion with their classes using the discussion materials found in Appendix B.

Group F did not view the films.

Groups A, B, C, D, E, and F were post-tested with the Allison adaptation of the "Allen Attitude Scale" in December, 1965 at the conclusion of the showing of the ten films.

Groups A, B, C, D, E, and F were tested again in April, 1966 at the end of ten additional weeks to check for retention of any attitude gain.

Conclusions

1. Attitudes toward science, scientists, and scientific careers were changed favorably as a result of all the treatments given during a series of ten motivational films.

2. Some methods of treatment produced favorable change in attitude toward science, scientists, and scientific careers more rapidly than other methods.

3. Changes in attitude toward science, scientists, and scientific careers are not related to grade level.

4. Changes in attitude toward science, scientists, and scientific careers are not related to student's mental age as measured by "The Lorge-Thorndike Intelligence Tests."[4]

5. Changes in attitude toward science, scientists, and scientific careers are not related to the mean of the achievement scores as measured by the "Stanford Achievement Test."[5]

6. Changes in attitude toward science, scientists, and scientific careers are not related to the science achievement score as measured by the "Stanford Achievement Test."[6]

7. Changes in attitude toward science, scientists, and scientific careers are not related to the sex of the student.

8. Changes in attitude toward science, scientists, and scientific careers are not related to the student's plans to elect science.

9. Changes in attitude toward science, scientists, and scientific careers are not related to the science training of parents as recorded on the student's permanent record card.

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[4] Lorge, *op. cit.*

[5] Kelley, *op. cit.*

[6] *Ibid.*

10. Changes in attitude toward science, scientists, and scientific careers are not related to economic status of parents as determined by parents' job title as recorded on the student's permanent record card.

11. The treatments given either Group C (films plus multiple-choice questions) or Group D (films plus large group discussion led by the investigator) are best for producing rapid change in attitude toward science, scientists, and scientific careers over a twelve week period of time between pre-test and post-test. Group D treatment is more successful than Group C treatment.

12. The treatment given Group C (films plus multiple-choice questions) was best for producing attitude change toward science, scientists, and scientific careers over the twenty-four week period of time between pre-test and retention-test.

Concluding Remarks. The investigator feels that it has been firmly established that changes in attitude toward science, scientists, and scientific careers can be promoted by using the "Horizons of Science" films as the vehicle with fourth-, fifth-, and sixth-grade students. All four treatments used created change in attitude gain score to a significant level. However, the treatments given Group C (films plus multiple-choice questions) and Group D (films plus large group discussion led by the investigator) produced a significant difference in gain score of attitude toward science, scientists, and scientific careers in the twelve week period between pre-test and post-test over control Group A (no films, no treatment), while treatments given experimental Group B (films only) and Group D (films plus class discussion led by classroom teacher) produced no significant difference in gain score in the same twelve week period. All four experimental treatment groups (Group B, C, D, and E) had significantly higher gain score means than control Group A over the entire twenty-four week period between pre-test and retention-test Only experimental Group C (films plus multiple-choice questions) had a gain score mean which was significantly higher than the gain score means of both control groups (Group A and Group F) and the gain score mean of experimental Group E (films plus classroom discussion led by classroom teacher) for the twenty-four week period between pre-test and retention-test.

The primary purpose for embarking on this project was to investigate a potential method of promoting a more positive attitude toward science, scientists, and scientific careers in students to a level where they would react more favorably toward science than they now do. The purpose was not to create more scientists and engineers, but rather to promote the acceptance of science so that the scientific literacy of the nation might be raised to a degree. However, if the gulf between the scientists and the non-scientist described by C. P. Snow in "Two Cultures"[7] is narrowed a little, then it might be assumed that more people will choose science as a career field.

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[7] C. P. Snow, The Two Cultures and the Scientific Revolution (New York: The Rede Lecture, Cambridge University Press, 1959).

Perhaps a personal experience will explain the above reasoning. About fifteen years ago, a girl informed this investigator that a girls' guidance counselor had advised her not to take physics because the guidance counselor had not understood nor liked physics when the counselor was a student in high school. The girl said that she had liked science to this point and wanted this investigator's advice since he was teaching physics. This was an extremely bright girl, who liked science and wanted to continue taking some more science courses, but was being steered away by the advice of someone who did not understand science or scientific endeavors due to lack of knowledge of them. Fortunately, for science and/or physics, the girl was extremely bright and willing to seek the advice of others. She was convinced that physics would not be too difficult for her and that she would enjoy it. The girl now has a Ph. D. in physics.

This investigator believes that the scientific literacy of our nation must be raised and the attitudes of our people toward science, scientists, and scientific careers must be made more positive. We do not want to convince good people who want to become lawyers, bankers, artists, writers, and members of other non-science related career fields to change to a science related career. Far from it, we need good people in these career fields, also. What we want to do is to keep those talented people who have a liking for, and an inclination toward a science related career from being directed away from their chosen career field because a positive attitude toward science, scientists, and scientific careers has not been promoted.

Recommendations

1. A comparison of attitude gains caused by treatment given "Horizons of Science" films with same treatment given a comparable film series written specifically for elementary school students.

2. The use of "Horizons of Science" films compared to a live presentation of the same script material by a science trained person using slides of the visuals.

3. The use of "Horizons of Science" films or a comparable series over a longer period of time to determine if the time interval between the same number of films would make a difference in the development of scientific attitudes.

4. Production of a similar film series specifically designed for elementary students.

5. Testing the people of this study after an elapse of time (months, and/or years) for either permanence or change of attitude toward science, scientists, and scientific careers.

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APPENDICES

APPENDIX A: MULTIPLE-CHOICE QUESTIONS

"VISUAL PERCEPTION"

1. The experiments in the movie demonstrate that
    (1) the hand is quicker than the eye
    (2) our past experiences help to determine what we think we we see
    (3) man can be taught to live in unusual surroundings
    (4) man never sees what he thinks he sees

2. A marble seems to run uphill
    (1) only at the Princeton Perception Center
    (2) when the path of the marble is through certain unusual rooms
    (3) only when trick photography is used
    (4) under no conditions

3. The true shape of a room can be determined
    (1) only by making accurate measurements
    (2) by looking at the room from all angles
    (3) only by viewing the room from above
    (4) by recognizing that our perceptions can be distorted

4. When we first observe and object, we attempt to
    (1) place it in true perspective
    (2) adjust it to fit our assumptions about the situation
    (3) determine its true distance and direction
    (4) determine anything unusual about the situation

5. If a white circle and a black circle of the same size were painted side by side on a wall, which circle would probably appear larger?
    (1) the white one
    (2) the black one
    (3) the white one only if both circles are painted above eye level
    (4) the black one only if both circles are painted above eye level

6. When you decide that one pencil on your desk is closer to you than another, you do so because
    (1) one is longer than the other
    (2) one is brighter than the other
    (3) one is much larger than the other
    (4) you have taken into account the surroundings

7. When viewing two balls, one of which is noticeably brighter than

the other, you are likely to assume that the brighter ball is
- (1) more nearly spherical than the dim one
- (2) closer to you than the dim one
- (3) moving toward you while the dim one is not
- (4) rotating while the dim one is oscillating

8. According to the film our ability to get along successfully in life is highly dependent upon
    - (1) our interpretation of how other people see the world
    - (2) binocular vision
    - (3) complete development of the five senses
    - (4) having faith in what we see

9. In learning about the world, we can benefit
    - (1) only from our own mistakes
    - (2) from our own mistakes and the mistakes of others
    - (3) only from the mistakes of others since we can never overcome our own misleading assumptions
    - (4) only from scientific observations free from any possibility of mistakes

"THE WORLDS OF DR. VISHNIAC"

1. In the movie Dr. Vishniac considers the living things in each of his many dishes as
    - (1) unimportant living things
    - (2) a complete world of living things
    - (3) just something to photograph
    - (4) small colonies of little animals

2. Dr. Vishniac has collected many color photographs as
    - (1) his library
    - (2) his hobby
    - (3) his decorations at his laboratory
    - (4) his decorations in his home

3. The living organisms Dr. Vishniac studies are found in
    - (1) cages in the city zoo
    - (2) dried sand
    - (3) cages in his laboratory
    - (4) a drop of water

4. Dr. Vishniac removes
    - (1) only plant life from his dishes
    - (2) only animal life from his dishes
    - (3) only the debris which would spoil the pictures
    - (4) all debris from the dishes

5. When he completes his study of a sample dish, Dr. Vishniac
    (1) returns the sample to a pond
    (2) washes the sample down a drain
    (3) throws the dish and sample in the trash
    (4) lets the sample dry up to kill the living things

"EXPLORING THE EDGE OF SPACE"

1. Of the following which is the most important conclusion from the balloon experiments?
    (1) Man is capable of surviving in space.
    (2) Cosmic rays are less dangerous to humans than to animals.
    (3) Space above the earth's atmosphere is dark
    (4) A man can perform continuous experiments for a period of at least thirty hours.

2. Why is it desirable to send a balloon above 99% of the earth's atmosphere?
    (1) To reach a region where the earth's atmosphere is very uniform.
    (2) To permit the determination of the exact shape of the earth.
    (3) To prepare for flights into space.
    (4) To make possible observations in space of the rising and setting of the sun.

3. Why are scientists not too discouraged by failures in their experiments?
    (1) They realize that they can learn from their failures.
    (2) Scientists have great control over their emotions.
    (3) They expect to work at least ten years before they achieve success.
    (4) Most of their work has been planned to take many years.

4. Why is the balloon launched from the pit in the iron mine?
    (1) To protect the balloon as it starts to rise.
    (2) To preserve the secrecy of the launching.
    (3) To minimize the effect of the earth's magnetism on the instruments.
    (4) To permit the balloon to take off under maximum atmospheric pressure.

5. Which of the following medical and psychological problems was a main subject of investigation during Major Simons' flight beyond 99% of the earth's admosphere?
    (1) Man's ability to survive on pure oxygen.
    (2) Man's reactions to being alone in space.
    (3) Man's ability to distinguish colors accurately at high altitudes.

    (4) Man's ability to judge distances accurately at high altitudes.

6. From the story of Mr. Winzen's work one may conclude that
    - (1) only by using new devices can significant new information about space be obtained
    - (2) most of the important developments in equipment for the study of space are made by members of the Air Force, the Army, and the Navy
    - (3) by using imagination, a scientist or engineer can modify available equipment for use in new research
    - (4) by intelligence and hard work man can conquer any scientific problem

8. Why is provision made so that the gondola with the experimenter can be released from the balloon by the ground command post?
    - (1) In an emergency the experimenter may be unable to operate the gondola release mechanism.
    - (2) The experimenter may be too busy performing experiments to operate the gondola release mechanism.
    - (3) At great altitudes men are too weak to operate a gondola release mechanism.
    - (4) People on the ground can predict more accurately where the balloon will go.

"FLOW OF LIFE"

1. The greatest advantage which the first forms of life had over today's complex organism was that they
    - (1) did not require a nervous system
    - (2) could absorb nutritive materials directly from their external environment
    - (3) consisted of a single cell
    - (4) performed chemical activities which were much simpler than those of complex organisms

2. Blood flow into a capillary is controlled principally by
    - (1) muscle cells in the walls of the capillary
    - (2) connective tissue fibers in the walls of the capillary
    - (3) a ring of muscle surrounding the capillary at its origin
    - (4) the rate at which blood is being pumped out of the heart

3. The blood vessels leading into the capillaries are twisted in order to
    - (1) bring nutrients to a large area of body tissue
    - (2) speed up the flow of blood through the narrow capillaries
    - (3) mix thoroughly the various substances contained in the blood

(4) reduce the pressure of the blood before it enters the narrow capillaries

4. The direction of blood flow in a capillary is
    (1) always from an artery to the nearest vein
    (2) always from a vein to the nearest artery
    (3) always in the same direction in any one capillary, though this direction may be from an artery to a vein or from a vein to an artery
    (4) in either direction at any particular time in any one capillary

5. If the human body were made so that all of the blood vessels were always completely filled with blood, the most significant result would be that
    (1) the heart would have to be four to five times larger than it is
    (2) the tissues of the bodies would be better nourished
    (3) one would have to breathe harder to supply the increased volume of blood with oxygen
    (4) the body weight would be greatly increased, which would in turn place a great strain on the heart

6. Scientists often have conferences on the problems on which they are working because
    (1) important scientific developments are never the work of a single man
    (2) it is not economical for two scientists to spend their time working on the same problem
    (3) other scientists might have useful suggestions related to the solution of the problem
    (4) scientists must be kept informed of the work of others in their field

"THE MATHEMATICIAN AND THE RIVER"

1. The river in the film is the
    (1) Nile River
    (2) Hudson River
    (3) Ohio-Mississippi-Missouri River System
    (4) Delaware River

2. The large model of the river made by the U. S. Army Corps of Engineers is made of
    (1) modeling clay
    (2) concrete
    (3) paper mache
    (4) mathematical formulas on paper

3. The model of each ten miles of the river constructed by Professor Eugene Isaacson and his fellow workers is made of
   (1) modeling clay
   (2) concrete
   (3) paper mache
   (4) mathematical formulas on paper

4. The reason for making models of the river is
   (1) to give people work
   (2) to sell more concrete
   (3) to train mathematicians
   (4) to help with flood control

5. At the time of the film
   (1) the concrete model was used to check the mathematical model
   (2) the mathematical model was used to check the concrete model
   (3) the concrete model only was used
   (4) the mathematical model only was used

"NEUTRONS AND THE HEART OF MATTER"

1. The nuclear reactor in the film is a source of and provides a stream of slow moving
   (1) electrons
   (2) protons
   (3) neutrons
   (4) none of the above

2. The particle accelerators shown are largely used to speed up two kinds of particles which are
   (1) electrons and protons
   (2) electrons and neutrons
   (3) protons and neutrons
   (4) none of these choices

3. Which of the following particles is unaffected by the negative swarms of electrons around the nucleus or the positive protons within the nucleus?
   (1) electrons
   (2) protons
   (3) electrons or protons
   (4) neutrons

4. The bubble trails photographed in the bubble chamber were left by
   (1) neutrons

(2) electrons or protons
(3) electrons or neutrons
(4) protons or neutrons

5. When the electrons, protons, or neutrons are mentioned in the film, it is said that these particles are
    (1) the same size as a molecule
    (2) the same size as an atom
    (3) smaller than an atom
    (4) larger than an atom

"NEW LIVES FOR OLD"

1. Anthropology can best be defined as the study of
    (1) primitive societies living in remote areas of the earth
    (2) man's capacities for change
    (3) man and his culture in all their forms
    (4) the relationships of primitive cultures to modern cultures

2. Dr. Mead's work with the Manus is most noteworthy in that
    (1) she was one of the first anthropologists to make use of motion pictures and other permanent records of a people's life
    (2) she had an opportunity to study changes in the lives of the same individuals over a period of many years
    (3) the Manus were one of the few surviving primitive cultures in 1928
    (4) the Manus had had little contact with the white man until Dr. Mead visited them

3. An anthropologist studies remote cultures for all of the following reasons EXCEPT that
    (1) they provide an opportunity to study man's adaptability to a great variety of conditions
    (2) they are simpler and therefore easier to understand than civilized groups
    (3) we can take the solutions made by primitive society and apply them directly to our own society
    (4) we can learn what man's life was probably like in the remote past

4. Which of the following kinds of additional information would be most helpful to modern Americans in trying to profit from the example of the Manus?
    (1) a knowledge of the racial classification and racial characteristics of the Manus
    (2) a knowledge of the reasons why the Manus originally

built their houses on stilts over the water
(3) a knowledge of the religion practiced by the Manus before they were introduced to Christianity
(4) a knowledge of the factors which were influential in bringing about the profound changes which have occurred in Manus life

5. Of the following the most important change which took place in life among the Manus between 1928 and 1953 was that
   (1) the people began to settle their difficulties in an orderly way, instead of fighting and threats of sorcery
   (2) the people could no longer be considered seafaring people
   (3) children learned to walk at an earlier age
   (4) children became able to play with balls and animals

"PROJECT MOHOLE"

1. Why will scientists probably drill through the Mohorovicic boundary at a point under the ocean rather than on land?
   (1) The ocean water can probably be used to cool the drilling apparatus.
   (2) The crust of the earth is thinnest under the ocean.
   (3) There is less risk to the scientists when underwater explosions are used.
   (4) The earth on the ocean floor is softer than the earth on dry land.

2. The VEMA's purposes in taking a core sample of the earth on the ocean floor include all of the following except to
   (1) get evidence as to the nature of the ocean bottom at a possible drilling site
   (2) get evidence as to the actual age of the earth
   (3) get more complete records of the evolutionary development of life forms
   (4) locate new underwater oil fields

3. The surface of the earth under the oceans
   (1) has been smoothed by the action of the water over long periods of time
   (2) has been plotted accurately by means of seismic records
   (3) has deeper canyons and taller mountains than the continents
   (4) is somewhat smaller in area than the land area of the continents

4. It is best for the four ships to work as a team in making seismic recordings because

- (1) it is too dangerous for any one ship to carry all the necessary explosives
- (2) recordings of the reflected sound waves must be made at different distances to understand the nature of the earth's upper layers
- (3) each ship has a different function: one carries the drilling rig, one the coring equipment, one the explosives, and the last the recording equipment
- (4) the number of scientists and technicians involved in making all the determinations needed for the project is so great that one ship could not carry them

5. Project Mohole can make a unique contribution to our knowledge of the earth in that it should
    - (1) demonstrate whether the drilling techniques developed by the oil industry can be applied to underwater drilling
    - (2) reveal whether the sound waves produced by dynamite explosions travel faster or slower in the deep layers of the earth than at the surface
    - (3) produce the first direct evidence as to the nature of the earth's interior
    - (4) provide more accurate information as to the shape of the earth

6. The speed at which sound waves travel is
    - (1) used to measure the age of the sediments under the ocean
    - (2) used to locate fossils in the sediments under the ocean
    - (3) greater in the deep rigid layers of the earth than in less rigid layers
    - (4) greater in water than in the earth

"THE REALM OF THE GALAXIES"

1. Some nebulae were proved decisively to be independent galaxies when astronomers discovered that
    - (1) these nebulae contain Cepheid variable stars whose distances could be determined
    - (2) these nebulae consist of separate stars rather than a mass of gas and dust
    - (3) the universe is expanding continuously
    - (4) our solar system is located at the edge rather than at the center of the Milky Way

2. The 200-inch telescope is located high on Palomar Mountain for all of the following reasons EXCEPT to
    - (1) avoid interference from the strong night illumination of cities
    - (2) shorten the distance to the stars which are to be observed

   (3) prevent distortion of the view of the skies by irregularities in the heavier lower layers of the earth's atmosphere
   (4) avoid a reduction in visibility because of fog

3. Why is the telescope provided with a motor and clock mechanism to move the telescope westward at a constant rate?
   (1) To enable the astronomer to photograph during one night a larger portion of the skies than would otherwise be possible
   (2) To give the illusion of motion to a series of time-lapse photographs of a section of the sky
   (3) To compensate for the movement of the stars westward during the night
   (4) To compensate for the effect of the earth's rotation eastward during the night

4. Why must the astronomer keep a guide star centered in the cross hairs while using the telescope?
   (1) To compensate for the effect of the earth's rotation on the image of the sky
   (2) To make sure that the night assistant has set the co-ordinates properly
   (3) To compensate for distortions produced by changes in the earth's atmosphere
   (4) To have a basis for comparing the sizes of the stars he is observing

5. Why does the mirror of the 200-inch telescope at Palomar have a hole in the center?
   (1) To decrease the total weight of the Pyrex mirror
   (2) To increase the potential magnification of the telescope
   (3) To allow the astronomer to see through and observe the image being focused on the photographic plate
   (4) To provide the only suitable space for the installation of a photometer to measure the apparent brightness of the stars

6. Astronomers are anxious to locate new Cepheid variable stars because these stars can be used to
   (1) estimate the age of the universe
   (2) determine the distances to the galaxies
   (3) determine the sizes of the galaxies
   (4) determine the chemical composition of matter in the galaxies

"THINKING MACHINES"

1. To be classed as a "thinking" machine, a machine must be able to
    - (1) defeat a man at a complicated game
    - (2) learn from its past experiences
    - (3) perform activities previously done only by men
    - (4) solve computational problems very quickly

2. One thing that all of the "thinking" machines in this film have in common is that each
    - (1) shows evidence of remembering
    - (2) improves its performance when it does the same assignment several times
    - (3) performs a task which men can do only with great difficulty
    - (4) depends on a highly trained operator to show its "thinking" ability

3. An advantage that a neuron has over a transistor is that the neuron
    - (1) has more connections than a transistor
    - (2) has no electrical properties while a transistor has
    - (3) has a longer life than a transistor
    - (4) can be studied more easily than a transistor since it is larger

4. A computer is LEAST likely to be of use in solving which of the following problems?
    - (1) Making weather predictions on the basis of meteorological readings
    - (2) Diagnosing illnesses on the basis of patients' symptoms
    - (3) Devising circuits for improved television receivers
    - (4) Tracking the course of artificial satellites

5. The artificial mouse was unable to run the electronic maze without errors the first time it was placed in it because
    - (1) the electromagnet mounted on the carriage was not properly activated
    - (2) it had no information as to the nature of the course to be run
    - (3) the maze was originally extremely complicated
    - (4) the circuits were designed to prevent the mouse from finding its way out on the first trial

6. The chess-playing machine, the mechanical mouse, and the pattern recognizer can each do all of the following EXCEPT
    - (1) duplicate one or more aspects of human reasoning processes
    - (2) operate automatically once it has been given the necessary instructions

(3) solve a wide range of problems
(4) always give the same answer when faced with identical problems

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APPENDIX B: DISCUSSION MATERIALS

"VISUAL PERCEPTION"

1. How do you think that a "perception" differs from "sensation"? Which do you think usually comes first?

   A dictionary says that sensation is the direct result of the present stimulation of the sense organs, as distinguished from perception, which involves the combination of different sensations and the utilization of past experiences in recognizing the objects and facts from which the present situation arises.

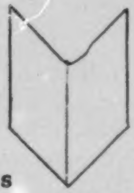
2. The things you see a magician do and the things which Dr. Cantril demonstrates are both surprising. How do the purposes of the two differ?

   The magician's purpose is to amuse by confusing. Dr. Cantril's demonstrations have been arranged to provide data on the learning process, on the functions of the eye and the mind and the relations between them in perception, and on problems of interpreting that one "sees."

3. Why do you think it is important that we understand the way in which our perceptions are formed?

   All that we learn comes through our perceptions, and so by understanding the process of perceiving, we can begin to understand learning.

4. Perhaps you have seen some optical illusions in a book. A familiar one is shown at right. How do the experiments in the movie differ from some of these optical illusions?



   Some optical illusions are effective because of the way in which the lines are drawn or the areas are shaded; the construction leaves open two interpretations. The experiments in the film do not possess such an ambiguity as this. Rather, we see things as we have come to expect to see them despite the fact that they differ from our expectations. The experiments are specifically constructed to provide scientific information about these differences.

5. Suppose that you are standing in a narrow street. A car in the distance appears to be growing larger.

(a) What changes might cause this appearance?
(b) Which do you think more likely?
(c) Can you always stand in the middle of the street long enough to make sure?

The illumination on the car may be getting brighter, or the car may be moving closer. Probably the car is getting closer. But the danger of getting run over may be too great to permit us to stay in the street until we have determined that the car really is getting closer. We must act on faith in many cases.

6. In judging whether an object is moving closer to you, which gives the better clue, changing size or changing brightness?

Most people find changing size more important than changing brightness. You might ask the students whether they thought the balloons seemed to be moving more when their sizes were changing or when the illumination on them was changing. Perhaps the class responses can be used to help the student to understand that there are individual differences in perception and that Dr. Cantril's conclusions could not properly be drawn from studies with a single person.

7. Suppose that a baby is brought up in a house built with rooms like the one in which Jackie and Malcolm walked around?

(a) How do you think this child would see this room?
(b) How do you think such a child would behave when first placed in what we call a normal room if this happens when the child is several years old?
(c) How can the differences between what such a child considers a normal room and we consider a normal room help us to understand our own perceptions?

This question is designed to help students realize that what is "normal" depends on our past experiences and that a child reared in surroundings different from ours would undoubtedly consider some of our perceptions and actions "abnormal." This child in a "normal" room might find that the floor seemed to "tilt" in a strange way.

8. What are important factors in making the rotating window appear to oscillate?

The window must have a constant speed of rotation. The ratio of the length of one end to the length of the other must be such that the larger end always appears closer.

The mullions must be painted so that there are "shadows" on them. (Warning: no matter how well this is done, it may not fool everyone. Zulus--who live in circular houses and are unfamiliar with rectangular windows--seldom see anything strange in this demonstration. They do not make the same assumptions that we do).

9. Have you ever watched a boy make his first tosses of a basketball at a basket? How is his performance related to perception?

Dr. Cantril's experiments seem to indicate that we learn best by purposeful activity and that "we can at times only learn through making mistakes--or sharing the mistakes of others. Mistakes are really the best opportunities for learning we have."

"THE WORLDS OF DR. VISHNIAC"

1. Dr. Vishniac is an outstanding example of an independent investigator rather than a member of a research team.

(a) What advantages are there to such a plan for research?

The research may move in the direction and at the speed that the individual finds challenging and suitable. Thus, the potential of a brilliant scientist can be fully realized.

(b) What disadvantages can you think of?

Some researches require equipment which necessitates the cooperation of others. Other people may be able to contribute important ideas toward the understanding and the development of the work. The number of man-hours needed for some research is too great for one man to be able to complete the work alone.

(c) Can you think of ways in which Dr. Vishniac might collaborate with others who do research in fields other than microbiology?

He is competent in the field of cinebiology and he has done the photographic work for other researches where such a record is essential.

2. Suppose that somebody tells you, "Visual observation is much less important to scientists today than it was a hundred years ago."

Would you agree or disagree? Why?

Visual observation remains very important. (1) Much of the education of most scientists comes from reading. (2) In fields like that of Dr. Vishniac there are studies which are impossible without visual observation even in an era when abstract mathematics is increasingly important. (3) Even in other fields meters, gauges, and records produced directly by instruments must be visually observed.

3. (a) In what fields might studies such as those conducted by Dr. Vishniac have applications?

   Learning about the transmission of disease, fermentation, discovery of antibiotics, exploration for oil. (Some fossil protozoa are good indicators of oil-bearing strata).

   (b) Do you think that Dr. Vishniac undertakes his studies with these applications in mind?

   Not primarily. He is interested in learning more about the microscopic organisms regardless of any immediate application. Applied science is highly dependent on "pure" research--and vice versa.

4. Dr. Vishniac does not use an electron microscope. Can you think of any reason why not?

   He is interested in studying live organisms. The beam of electrons kills living specimens. Dr. Vishniac is extremely careful to keep the organisms alive and "happy" under the optical microscope.

5. Suppose that you were to hunt samples of protozoa like those shown in the film. Where should you look?

   Any water that has not recently been subjected to purification processes will suffice. Water that is stagnant is likely to contain more microscopic life than rapidly moving water.

6. What does Dr. Vishniac mean by saying that he has a "whole balance of nature" in one of his dishes?

   The dishes contain both plants and animals, and each dish illustrates the interdependence of the plants and animals. The plants need the carbon dioxide given off by the animals and the animals need the oxygen given off by the plants.

7. What do you think Dr. Vishniac means when he says that protozoa may be "the same pinnacle of evolution as humans are"?

   Protozoa are a type of animal that has had a very long history on earth. The species now present have successfully solved the problems of continued existence. On the level of animal organization which they represent, they may have solved these crucial problems as successfully as man. Evolution is a continuing process. Protozoa are far older than man--and far from "simple" in their form or behavior.

8. From what he says in this film can you guess whether Dr. Vishniac accepts the theory that all life came from a common ancestor?

   He believes that the multiple origin of life is more likely and that the great diversity of protozoa is better explained if one does not postulate that these creatures are the ancestors of all animal life.

9. On the basis of what you observed in the film can you suggest ways in which protozoa may be classified?

   When a scientist classifies organisms, he groups those that are alike together. For example, protozoa are those animals which consist of one cell. Classifying organisms may seem like a simple procedure. However, there are all sorts of difficulties. The most serious problem is due to the fact that organisms resemble each other in many different ways. This becomes obvious when we look for ways to subdivide the protozoa into groups. Several ways in which this might be done come to mind. We might base our classification system on size. Or we might put the protozoa into two groups depending on whether or not they live by themselves or in colonies. Actually, biologists have divided the protozoa into four groups depending on the nature of their locomotion:

   (1) FLAGELLATES - those that move by means of one or more flagella
   (2) SARCODINES - those which move by means of temporary extensions called pseudopodia or false feet
   (3) CILIATES - those which move by the coordinated beating of many short hair-like projections of cytoplasm called cilia
   (4) SPOROZOANS - those which have no special organs of locomotion

   Biologists consider this system of classification superior to others which might be set up because they think it best represents the true evolutionary relationship of the protozoa.

10. Much of the material inside the cell is called protoplasm. This word, like a number of other biological words, comes from the Greek and the Latin. Proto means first, plasm means that which is formed. Can you think of other words which have these same word parts in them?

    Protozoa (first animals), prototype (the original), proton (first particle), plastic (capable of being formed).

"EXPLORING THE EDGE OF SPACE"

1. Research is sometimes divided into two classes: basic and applied. Basic research seeks to supply new information about nature, regardless of whether this information is immediately useful or not. Applied research is directed toward the finding of an answer to a problem where the answer will be immediately and obviously useful. Determining gravitational acceleration is fundamental research; developing a better tread for snow tires is applied research. Into which of these classes does most of Mr. Winzen's work go? Is the other class represented at all?

    The development of large plastic balloons and learning how to handle them effectively is applied research. Some of the information that is obtained from the instruments taken aloft by the balloons is certainly basic research.

2. Can you think of some of the kinds of measurements or studies that might be done in a balloon that would be called basic research?

    Determination of how cosmic radiation varies with height; learning more about what sorts of rays and particles are present in cosmic rays; learning how the gravity changes with height; taking pictures of the sun and moon above most of the earth's atmosphere; determining how the density of the atmosphere (or its pressure) changes with height; determining how the amounts of the different gases change with changes in height--all are basic research.

3. (a) What are some advantages of balloon ascensions for research?

    Instruments and equipment can be sent to heights miles above the earth's surface and then may remain at nearly the same altitude for a long enough time to permit observations and measurements which are not possible from a rapidly moving craft. With the techniques developed by Mr. Winzen a whole laboratory may be able to work at great heights for a number of hours or days.

(b) What are some disadvantages?

Balloons cannot ascend beyond the earth's atmosphere. Balloons cannot be directed to any location one may desire. Locations where balloon launchings are possible are limited.

4. After you have learned something about the history of ballooning, consider these questions.

(a) What have been the principal uses of balloons through the years?

Balloons have been used principally by adventurers and sportsmen to provide an unusual and exciting experience. There have been exceptions (Explorer II of the National Geographic Society and the U. S. Army Air Corps in 1935), but most balloon flights have been for thrills and fun.

(b) What does Mr. Winzen's work with balloons show about the methods of science?

A new technique of real importance may develop from a very unexpected background. The balloon as a research tool has emerged, after much effort by Mr. Winzen, from the balloon which was little more than stunt equipment. Similarly, x-rays for research developed from an accidental observation by Roentgen in his laboratory.

(c) What does Mr. Winzen's work show about the relation between applied research and basic research?

Success in applied research may make new basic research possible. Some things about the upper atmosphere, for instance, could not be learned until balloons to go there and stay there were available. In the same way, glass technology had to be very advanced before a 200-inch telescope for basic research could be made.

5. The pictures you saw should suggest some things about how Mr. Winzen has worked and about how some scientific activity must be carried on. What did they suggest to you?

Teamwork has been very important in the balloon developments. The pictures of the ascensions show how many people must help, each doing a small part. Other cooperation has taken place behind the scenes. One person alone cannot prepare such balloons, or develop the needed equipment, or interpret the results of the measurements made, or provide the money needed. Industry, universities, and the Armed Forces have all cooperated. Some research must be team research. Mr. Winzen must be a man who can work effectively with others.

6. Why must the upper atmosphere be considered to be an environment hostile to man?

   The atmospheric pressure is very low. The supply of oxygen is extremely limited. Cosmic radiation is hazardous. One's freedom to move must be very limited.

7. What must be the properties of a good space capsule for a man?

   It must provide oxygen and adequate pressure for him. It must shield him from cosmic rays. Temperature control must be considered. Carbon Dioxide and water vapor content must not get too high. The man must be able to do his work. He must not be in a very uncomfortable position which he cannot change. The capsule must not be too heavy.

8. What properties are needed for good balloon material?

   The gas must not leak out and air must be kept from seeping in. The material must remain usable through the range of temperatures to be encountered. The material must be strong enough so that the chance of ripping is kept small. It must be light.

9. Can a balloonist do anything to control the direction in which his balloon moves?

   The balloonist can control vertical motion fairly well. He drops ballast to increase the rate of rise and he releases gas from the balloon when he wants to drop. Horizontal motion is very largely controlled by air currents although low-flying balloons drag a rope to slow their movement in an undesirable direction.

"FLOW OF LIFE"

1. Why do you suppose that the capillary bed consists of such an intricate branching network of very fine microscopic vessels

rather than a few direct connections between the arteries and the veins?

Careful observation of the capillary bed shows that every cell of an organism lies close to a capillary. Without this contact between the cell and the fluid supplied by the capillary the cell dies. The end result of circulation in higher animals is that nutrient media are placed within close diffusion distance of every body cell. In this way the organism duplicates to some extent the water environment of single-celled organisms.

2. What must a cell in a multicellular animal receive from the blood?

   Food, water, and oxygen must be delivered to the cell. Waste products, both gaseous and solids, must be removed from the cell. The blood must provide some protection to the cell from infection. In addition, the blood serves the important function of keeping every cell constantly bathed in a physiological solution which enables the cell to maintain its normal shape and plasticity.

3. Dr. Zweifach reports that the combined length of the capillaries is about 60,000 miles (2.4 times around the earth at the equator) and that if all the capillaries were concentrated, they would make up the largest body organ. Yet the total volume of blood for a 150-pound man is only about 11 pints. How can such a small amount of liquid serve such a large number of capillaries?

   Probably the major reason--and one very well illustrated in the film--is that the capillaries are open only a part of the time. Thus, many capillaries have no blood in them at any one instant. A second important reason is that capillaries have very small cross-sections and so contain very little blood even when filled. Actually the bulk of the blood at any given moment is in the arteries and veins--in transit to and from the capillaries. In his article Dr. Zweifach says that it takes one cubic centimeter (only about 13 drops of blood) as long as five to seven hours to flow through a single capillary. Thus, a small amount of blood can supply many capillaries.

4. How does Dr. Zweifach justify his view that the capillaries are the most important part of the circulatory system and that the heart and large blood vessels are principally a pump and pipes to provide blood to the capillaries?

The prime purpose of the blood is to serve the individual cells of the body. The exchange of materials between the blood and the cells takes place only through the capillary walls. The circulatory system was created for this specific purpose. The heart and large blood vessels are essentially the plumbing to enable this system to operate.

5. It is possible for an animal to "bleed to death" without a drop of blood leaving its blood vessel. Can you think of a possible explanation for this phenomenon?

   Remember that the total volume of the blood vessels is much greater than the volume of blood which circulates through the vessels. In shock, the arterioles in the abdominal area dilate and the blood accumulates here. There is not enough blood still circulating to bring oxygen to the brain and other vital organs. Unconsciousness and death can result.

6. The film shows a seminar of scientists discussing a research program. One of the reasons for such sessions is that a scientist learns about the research of his colleagues. Another method which is very important for learning about research activities is the reading of scientific journals. What advantages do you think each of these methods has?

   The seminar has the advantage of face-to-face discussion between the participating researchers. The formal presentation of research methods and results usually opens such a meeting, but questions and answers with an interchange of views and ideas normally are part of the meeting, and these may be valuable to the speaker as well as to his questioners. Furthermore, enthusiasm may develop at a good seminar that does not emerge from any other experience. Research is often slow and discouraging, so an activity that helps to create interest and new ideas is important.

   The reading of journals is the only way of learning about the research work of people who cannot attend such seminars. Research is done in many countries, and a scientist can keep up only by reading reports--often in foreign languages.

"THE MATHEMATICIAN AND THE RIVER"

1. What are some important factors which determine the rate of flow of a river at a particular point on the river?

(a) The cross-section of the river at this point
(b) The nature of the river bed at this point (The resistance to flow is determined by the nature of the river bed)
(c) The sizes of the channel both upstream and downstream from the point
(d) The amount of water reaching this point from upstream

2. If Dr. Isaacson can write equations which are useful in predicting the river's behavior, why should the concrete model at Jackson, Mississippi, be maintained?

   The conclusions reached by the use of the mathematical equations can be checked by the use of the concrete model. Opportunities to check the calculations against disastrous floods are fortunately few. But with the concrete model, tests can be made safely and as desired.

3. What are some of the advantages of the great reduction in scale of the concrete model as compared with the river itself?

   (a) The smaller the model the less expensive and the easier it is to construct.
   (b) The maintenance cost is less when the model is small. The rivers are not static. They keep changing their beds. On a small model these changes can be made without great cost.
   (c) When the river is compressed, studies can be rapidly made to determine just where the greatest hazards in the case of a particular flood are. The model compresses time as well as distance. The larger the model the slower the process of determining points of stress. Furthermore, if a levee gives way, this change can be quickly made in the model and the effect on river levels above and below the break can be estimated.
   (d) The model permits one to "see" and so begin to appreciate the nature of a sizable portion of the river at one time.

4. Are there any advantages in having the model as large as it is (one step equals one mile) rather than being much smaller? After all, a smaller model would be less costly still.

   When a model of this sort is made smaller, the accuracy of the model is necessarily made less. As a result, predictions based on it become less sure.

5. Suppose that a prediction is made from the mathematical model. Further, suppose that when a test of the prediction is carried

out by using the concrete model, the results do not agree with the prediction. What would you think important steps to improve this situation would be?

(a) Studies should be made to determine which of the models is in error. The equations may be either more or less accurate than the concrete model.
(b) An important step in this study would be to recheck the data on which the models are based: the river contour, resistance, rate of flow, quantity of water, and so forth.
(c) If the mathematical model is less accurate than is necessary, it could be made more accurate by shortening the length of river for which a set of equations is written.

6. Work on flood control of the Mississippi has been helped by the use of the concrete model of the river. Should a model of this sort be prepared before undertaking all engineering projects?

   Cost must be considered. A concrete model may be very expensive. In some cases an adequate mathematical model can be prepared by using previous experience and the judgment of experts. Such a model is commonly much less expensive to prepare.

7. Suppose that at some time in the future one river model or the other is abandoned. Which model would you guess is most likely to be abandoned?

   The mathematical model is much more compact. It can be changed very quickly and inexpensively as compared to the concrete model. By using computers one can get the predictions of the mathematical model in a very short time. After it has proved itself, this model would appear to be the more useful.

"NEUTRONS AND THE HEART OF MATTER"

1. In the study of the properties and experimental uses of neutrons, as shown by the film, what is the purpose of the (a) nuclear reactor? (b) fast chopper?

   (a) The Brookhaven nuclear reactor provides continuous streams of neutrons for research much as a tea kettle produces steam. The reactor itself consists of a massive cube of graphite blocks penetrated by rods of uranium fuel. The chain reaction which automatically takes place within the "critical mass" of uranium is regulated by movable control rods of cadmium.

The reactor has a number of different types of facilities for neutron experiments. A system of pneumatic tubes allows scientists to place materials inside the reactor where they become radioactive and can be withdrawn and used for experiments in radiation. The entire "pile" is pierced by numerous channels which penetrate to different depths inside the reactor. When these channels are opened, they provide neutron beams of different intensities for experimental use.

(b) The fast chopper breaks up a beam of neutrons into tiny bursts. Each burst consists of many neutrons traveling at different speeds. The speeds of neutrons in each burst can be measured . . . the fastest (highest energy) neutrons arrive at the detector first. The slowest (lowest energy) neutrons arrive later. By placing a sample in the chopped neutron beam, we find that certain energies (speeds) of neutrons are stopped by it, and other energies pass through. This pattern of neutron absorption is reflected in the curves seen on the oscilloscope screen, charted by the plotter and printed in the "barn book."

2. How are the accelerator and the bubble chamber used for studying subatomic particles and nuclear structure?

"Atom smashers" are machines which create projectiles fast enough and small enough to penetrate the atom and smash the nucleus. These atomic bullets can be aimed at a target placed within the machine, or can be guided to a piece of special measuring equipment such as a bubble chamber. When the target is bombarded and nuclei are hit, the particles which make up an atom are broken down into still smaller particles.

The complex hydraulic and electronic circuits of the bubble chamber create the right conditions for capturing on film the fleeting instants of nuclear events. Such photographs show the bubble trails left by the passage of speeding particles. When particles collids, the directions they "bounce" or "ricochet" give us clues to their speed and mass. When a magnetic field is created in the bubble chamber, it causes the trails to curve, giving us an indication of the particles' electric change. Such subatomic "events," seen as trails spreading from the point of impact, have revealed that in addition to electrons, protons, and neutrons, a whole new set of "elementary" particles can be created. Most of them exist outside the atom for only a fraction of a millionth of a second before they "decay" into other particles or change completely into energy. As we build larger and more powerful machines, we seem always to find still newer and stranger particles.

3. Why are neutrons in some ways better than protons or electrons for studying atomic nuclei and "probing the heart of matter"?

   If we try to visualize an atom, we must imagine a swarming cloud of electrons occupying most of the space, each bearing a negative electric chage. The protons within the tiny central nucleus are positively charged. Neutrons have no electric charge and are therefore unaffected by either the negative swarms of electrons around the nucleus or the positive protons within the nucleus. They can pass easily through dense matter even though they are traveling at relatively slow "speeds."

4. Why do you suppose that protons and electrons are the particles which are accelerated in "atom smashers"? Why not neutrons?

   The very quality that makes neutrons so valuable as an experimental probe at the reactor--their lack of electric charge--makes them hard to accelerate. Charged particles (protons or electrons) are docile beasts. We can speed them up with electric fields. We can steer them and aim them with magnets. In some experiments they are easier to measure, for they announce themselves directly by leaving ion trails in cloud chambers or bubble trails in bubble chambers. These trails when photographed and analyzed can give us much additional information about the interaction of subatomic particles. At such high speeds the electric charge of particles has little effect on their penetrating power.

5. A note on Quantum Mechanics.

   One of the dramatic scientific advanced in the past half century was the discovery that subatomic particles behave both as waves and as particles. This discovery led to the development of the laws of quantum mechanics. In the subatomic world electrons, protons and neutrons have this two-sided nature as particles and as waves. Their behavior cannot be described or understood very well in terms of familiar objects. For instance, neutrons traveling at relatively slow speeds (such as those produced by the neuclear reactor) lost their particle characteristics almost completely and act as if they were waves alone, very much like light or sound. In fact, practically every phase of the behavior of light waves can be duplicated in experiments with slow neutrons. On the other hand, when electrons or protons are speeded up in an accelerator, they act almost completely like particles. At such speeds their behavior seems not at all wavelike and they can be truly considered as subatomic "bullets."

Perhaps even more difficult to understand is the fact that these subatomic particles change their mass and size as their velocity changes. Thus when a particle gains speed, its mass increases and its size decreases. When a particle is slowed down, on the other hand, its mass decreases, its size increases, and it begins to act more like a wave. The sizes and speeds involved here are of course almost beyond our comprehension . . . our basic ideas of mass, size and speed become difficult to apply in the subatomic world. The famous Einstein formula, $E = mc^2$, was man's first expression of these relationships and laws in the subatomic world.

"NEW LIVES FOR OLD"

1. What is meant by the word "culture" when used by an anthropologist?

The anthropologist uses the word "culture" in a technical sense to mean all of the learned behavior of man--the habits, techniques, ideas, values and products which different groups of people have developed, and have learned from others. Culture may be thought of as the distinctive way in which human beings have become adapted to their environment, in contrast to other living creatures whose special adaptations--like fins or tusks--are part of their physical inheritance.

2. What does the anthropologist study?

Anthropology is the study of man, his physique, his culture, his language and his history. The cultural anthropologist is interested in the entire range of human behavior. For his laboratory, he uses primitive people who have transmitted their culture without the help of a written language. These small groups provide him with "living models" of how societies function and how human cultures develop and change. The anthropologist gets his training in understanding how whole societies work from these smaller and simpler ones. However, anthropologists also study modern societies, factories and hospitals, changes in immigrant groups, and the problems of communication among peoples who speak different languages, or have different values.

3. The dramatic changes in the Manus people came about as a result of the interplay of a number of factors. One was that the Manus Islands were used as an American Army base during World War II. Before this time the Manus had had contact with the Germans and the Australians. What characteristics of the Americans as compared with the Germans and Australians do you suppose particularly impressed the Manus?

   All these peoples were modern, highly organized with complex tools and weapons. From the German missionaries the Manus had gained a knowledge of the idea of human brotherhood. From the Australian governing officials under the League of Nations, an idea of modern medicine and modern law. But from the Americans they had their first experiences of being treated as full human beings, not as "natives," but as people. The American way of life they understood as one in which individual human lives were more valuable than any amount of property, where people managed their affairs democratically and without the need of continuous personal displays of anger, where almost all the infants lived to grow up, and people lived to old age because they had modern technical advances to help them.

4. An anthropologist must try to notice many, many things when he is at work. What are some of the seemingly small details of the life of the Manus which Dr. Mead has pointed out in the film?

   Ways of walking which indicate the different social importance of what people are doing.

   Ways of handling tools, showing the contrast between the traditional adze and the modern axe.

   The precise methods through which the Manus use the special rubber-like pulp of the paraminium not to caulk their canoes.

   The way a mother leaves her toddling child free to move, yet watches over him and stimulates him to further exploration.

   The details of the wedding ceremony, where wooden bowls have been replaced by enamel bowls, canoe platforms by tables, shouted insults by formal speeches, exchanges of food and dogs' teeth by pleasant presents to visitors, shame by quiet pride.

5. What can modern Americans learn from the example of the Manus as seen in this film?

   Margaret Mead's two visits to the Manus, separated by a span of twenty-five years, provided an almost unique opportunity to make a scientific study of change occurring in a human group. Because Dr. Mead was able to talk and work with the same individuals on her two visits, she could evaluate the change that had taken place with much more certainty. For Americans just entering the space age, it is extremely important to know how individuals can be transformed without losing their essential identity, how whole societies can change to meet new conditions.

"PROJECT MOHOLE"

1. What are some of the problems involved in penetrating the crust of the earth at a great depth under the ocean?

   Some way must be found to hold the drilling ship steady over the drill hole during operations--scientists estimate that the drill bit can be held steady if the ship drifts no more than 240 feet in any direction. The drill pipe must be sufficiently strong and flexible to resist the wrenching forces of the ocean currents. Tremendous quantities of drill pipe must be kept ready in racks as the drilling proceeds to greater and greater depths. Supply lines must be set up to keep the drilling ship stocked with needed equipment at all times of the year. But the fundamental problem is to develop a technique for drilling to the Moho, a depth never before reached by man.

2. Why should we spend so much money just to drill a hole through the crust of the earth?

   Much that we "know" about the structure of the earth's outer layers is only theoretical--it is based on inferences from many different kinds of measurements and determinations that have been made. The only way to get clear direct evidence is to examine actual specimens of the earth's mantle. And the only way to get these samples is to drill--perhaps more than 30,000 feet--down from the surface. Other valuable evidence should come to light at the same time. Much remains to be learned about the progress of evolution of life on earth. Only direct fossil evidence will give us answers to the questions that remain. We may learn about shifts which have taken place in the earth's magnetic poles or in the temperature of the oceans during past geologic ages. We may find clues as to the age of the ocean and its rate of growth. Still another factor to be considered is that there is a chance that Project Mohole will turn up some great unexpected discovery. If we turn to the history of science we find many instances in which unpredicted discoveries have upset accepted theories. These are some of the most valuable results of venturing into the unknown.

3. Some scientific research projects require highly trained men from only one or two fields. The work on Mohole is quite different from this. What are some of the fields of science and engineering which must supply experts if Mohole is to be completely successful? What do the representatives of these fields contribute?

   Seismologists are needed to plan the underwater explosions and to interpret the results.

   Oceanographers provide information on the floor of the ocean, and interpret the data obtained in the surveys, help to plan the surveys being made.

   Geologists study the cores obtained, combine these results with results from other locations, and seek to draw conclusions about the earth's history.

   Chemists perform analyses of core materials and help select materials for casings to be used in the drill shaft.

   Physicists and electrical engineers design the equipment for the sonar tests and for recording the results of other experiments.

   Other engineers design coring and drilling equipment. Naval architects design special oceanographic ships for oceanographic surveys and are working on plans for sea-going drilling rigs which will eventually drill the Mohole.

4. In the film's sequence on seismic surveying a major simplification was made for the sake of clarity in the diagrams showing the paths followed by sound waves. What was this?

   The diagrams suggest that the sound waves follow a single path. Actually the waves spread out in all directions from the source and from the surfaces from which they are reflected. The waves travel faster in the deeper, more rigid layers. Even though the distance is greater, the sound waves traveling past the Moho arrive at the listening ship first. The sound waves that travel by the most direct route, through the water, arrive at the listening ship last of all.

5. The radius of the earth is about 4000 miles. The radius of the inner core is about 800 miles, the thickness of the outer core is about 1400 miles, and that of the mantle is about 1800 miles. The crust is no more than 30 miles deep. Calculate the percentage of the earth's volume which is made up of the mantle.

The total volume of the earth is

$$\pi r^3 \; 4/3 = 4/3\,(3.1)\,(4000)^3 \text{ miles}^3 = 26 \times 10^{10} \text{ miles}^3 .$$

The volume of the two inner layers is

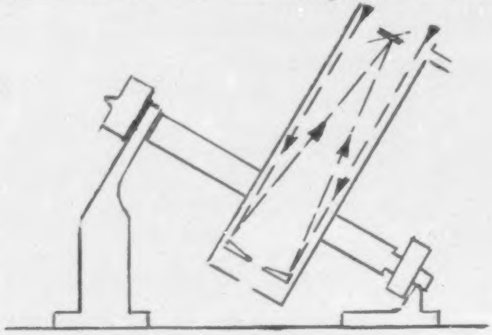
$$\pi r^3 \; 4/3 = 4/3\,(3.1)\,(2200)^3 \text{ miles}^3 = 4.4 \times 10^{10} \text{ miles}^3 .$$

This means that the volume of the mantle is about 22×10^{10} miles^3 and that the mantle makes up more than 80% of the volume of the earth.

"THE REALM OF THE GALAXIES"

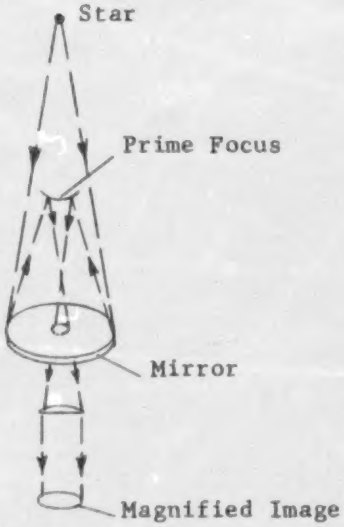
1. Draw a diagram to show the path of a beam of light from a star which is viewed in the Palomar telescope.

Although there are several different ways in which the beam of light can be handled in the telescope in order to make different sorts of studies, taking a photograph at the "prime focus" is the simplest method.



2. Why is there a hole in the mirror of the telescope at Palomar?

The 200-inch mirror of the telescope at Palomar is parabolic in shape. A mirror of this shape concentrates the light at the point of prime focus 55 feet above the mirror surface. Here the image can be observed or photographed. This image also may be magnified by using a convex mirror and reflecting the light from the point of a prime focus back through the hole in the center of the 200-inch mirror. A magnified image is thus produced at a point below the mirror surface. This larger image can then be photographed.



3. Time-lapse photography is a process of making moving pictures in which there is an appreciable interval of time between the exposure of each frame (separate picture) in the film. What are the advantages of time-lapse photography in astronomy? Should the time lapse be the same for all movies that might be taken using this technique? Can you see any difficulties in the use of this technique in astronomy?

Changes among the heavenly bodies seem to occur rather slowly because of the great sizes of the bodies and because of the distances between them. Time-lapse photography offers an opportunity of "speeding up" the motion. The length of the lapse that is most effective depends on the rapidity of the motion being studied. The time lapses for pictures of solar prominences need not be as long as those for taking pictures to show the motion of the satellites of Jupiter. A major problem in such photography is that the movement of the camera must compensate for the motion of the earth.

4. Why do astronomers use photographic plates and photocells?

The photographic plates give a permanent record of the observations made. Sometimes a survey of plates made some years apart reveals changes in the sky that would have been missed except for a comparison of the photographic records. The use of two photographic plates to locate Cepheid variables is well illustrated in the film. Furthermore, a plate may be exposed for some time, and a star that is too dim to affect the human eye may leave an impression on the plate if the exposure is long enough.

Photocells permit a quantitative measurement of the apparent brightness of a star. Otherwise one has to depend on the judgment of the observer. And different observers have a difficult time reproducing one another's judgment.

5. Describe the shapes of the galaxies which are shown in the film. Astronomers believe that galaxies are very slowly changing shape from open to closed forms. If this is true, which of the shapes must represent the youngest galaxies? What is the shape of the Milky Way galaxy?

   Galaxies show the following shapes: globular, elliptical, disk-shaped with a much thinner center than rim, bar-shaped with arms very nearly surrounding the bar, bar-shaped with arms rather wide spread, small-centered with arms spiralling out from the center. Those galaxies with far-flung arms are considered to be the youngest. The Milky Way galaxy has a disk-shaped center with arms which are neither extremely far flung nor tightly coiled around the center.

"THINKING" MACHINES

1. What are the advantages of constructing "thinking" machines?

   (a) Modern computers can and do carry on very rapidly many useful activities: solving mathematical problems, keeping books, controlling factory production and so forth. The development of this kind of "thinking" machine has been of great practical importance.
   (b) Some of these machines may provide insights into the operation of the human brain. They suggest further work in this field of fundamental research.

2. Why do you think that concentrated research on "thinking" machines has been going on for only the last ten years?

   Recent developments in the field of scientific instruments, particularly electronic advances, have made possible new types of equipment. Thus, progress in "thinking" machines could be extensive and effective for the first time.

3. What steps would be necessary to improve the performance of the chess-playing machine designed at IBM?

    A new program would have to be prepared and supplied to the machine. This program might be written so as to direct the machine to look farther ahead than four moves or to study in great detail eight possible moves instead of seven. Or perhaps a program could be devised which would prevent the machine from repeating moves that have proved fruitless.

4. Why do you think that an experienced chess player can beat the chess-playing machine?

    The experienced player has learned what is likely to result from certain moves; i.e., he learns from previous experiences. The machine cannot improve its performance on the basis of experience. The machine is dependent solely on its programmed instructions.

5. Why is it possible for the mouse to "learn" from its previous experiences whereas this is not possible for the chess-playing machine?

    The mouse machine has a less complicated problem to solve. In each unit of the maze there are only four possible directions for the mouse to move, even counting the possibility of the mouse leaving in the same direction as it entered. The designing of a machine that can learn the right action to take with respect to each of the units in the maze is much simpler than the programming of a machine to play chess where the number of possible games is much greater than the number of all the chess games that have so far been played in all the history of the game.

6. One computer expert says that a computer--a leading type of "thinking" machine is really only an extremely fast moron. What do you think this statement means?

    Computers do the steps which they can perform very rapidly. However, before a computer can do anything, a very detailed description of the steps to be performed must be prepared. Each step in this "program" must be a very simple step, the kind of instructions that one might give to a moron.

7. A text on computers states that a pencil and pad of paper

is really the most expensive of all available computing systems. Why do you think that the text makes this statement?

Though the raw materials for paper computation are very inexpensive, the amount of human energy required per calculation is much greater than the amount used for each calculation as done by a computing machine. Of course, this saving of human energy is significant only when many similar calculations, for which the machine can use the same set of instructions, are to be done.

8. Consider each of the following. Which of them do you think that a computer does?

    1. Learn what it is told
    2. Remember what it has learned
    3. React appropriately to a situation which it has not faced before
    4. Retain information indefinitely
    5. Classify or combine different pieces of information
    6. Carry out arithmetic calculations
    7. Meet unusual situations with judgment and discretion
    8. Check its work for accuracy
    9. Get tired and need rest
    10. Examine a set of results and decide on the next step

    Computers have been developed which carry out one or more of the following: 1, 2, 4, 5, 6, 8, 10. (Both the electronic mouse and the chess-playing machine illustrate 10). Computers do not do numbers 3, 7, 9. No computer yet has been developed which can react to stimuli for which it has not received instructions. Thus, it cannot react appropriately to a situation which is really new to it. Nor can it exercise what we usually call judgment and discretion. Computers can work 24 hours a day when they receive the necessary electricity and have had adequate maintenance. Of course, shutdowns are needed for maintenance and repairs.

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APPENDIX C: ALLEN INVENTORY OF ATTITUDES TOWARDS SCIENCE AND SCIENTIFIC CAREERS*

1. Science is not sufficiently appreciated by most people.
2. Science is a systematic way of thinking.
3. Scientists are seldom concerned with their working conditions.
4. The development of new ideas is the scientist's greatest source of satisfaction.
5. Friends often discourage girls from taking high school science courses.
6. Science and technology are essential to the development of present day cultures.
7. Increased radiation resulting from bomb tests is a threat to civilization.
8. Scientists are too narrow in their views.
9. Industries use research as a means to improve their economic position.
10. The application of scientific knowledge to the development of new industries enriches society.
11. The President's cabinet should be enlarged to include a Secretary of Science.
12. Scientists and engineers should be eliminated from the military draft.
13. The scientist will make his maximum contribution to society when he has freedom to work on problems which interest him.
14. A scientist might aptly be described as a non-conformist.
15. Scientists should be looked upon as "subjects for suspicion."
16. Scientific investigations are undertaken as a means of achieving economic gains.

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17. To become a scientist requires superior ability.

18. Science requires creative activity.

19. Scientists are willing to change their ideas and beliefs when confronted by new evidence.

20. Scientists have unusually intelligent mothers.

21. Scientists are "longhairs."

22. The complexity of science hides its cultural values.

23. Modern science is too complicated for the average citizen to understand and appreciate.

24. Scientists possess too much power in our society.

25. Decisive economic, political, and social processes are greatly influenced by science.

26. It is undemocratic to favor exceptional scientific talent.

27. The monetary compensation of a Nobel Prize Winner in Physics should be at least equal to that given popular entertainers.

28. Hazards created by the increased use of radioactive materials make scientific work less attractive than previously.

29. Scientists are shy, lonely individuals.

30. Loyalty checks and security clearances have seriously interfered with the work of scientists.

31. For me, training for a career in science is not worth the time and effort required.

32. Science is primarily a method for inventing new devices.

33. Scientists are more emotional than other people.

34. Girls have very little mechanical aptitude, and therefore should not consider scientific careers.

35. Scientists are honored persons who stand very high in popular prestige.

36. To appreciate modern society fully, a person must understand the importance of science.

37. Scientists are an "odd" lot.

38. Science without mathematics is impossible.

39. Science is the greatest unifying force among nations.

40. Maintenance of scientific work is essential to national survival.

41. The use of scientific achievement is often hampered by selfish individuals.

42. Scientific work is boring.

43. Scientific activity is greatly influenced by culture.

44. The free flow of scientific information among scientists is essential to scientific progress.

45. Scientists display an almost irrational attachment to their work.

46. I don't have the intelligence for a successful scientific career.

47. The winning of the esteem of his associates is one of the main incentives for the scientist.

48. Scientific findings always lead to final truths.

49. Scientists are as concerned as are other groups with the policies of the company for which they work.

50. Industrial developments are based more on practical experience than on laboratory research.

51. The scientist can expect to accumulate little wealth as compensation for his work.

52. Science is a man's world; there is little room in it for women.

53. Science is primarily responsible for the frequent changes which occur in our manner of living.

54. Scientists are "eggheads."

55. Scientific work requires long years of labor and self-discipline.

56. A great research scientist is little concerned with the practical application of his work.

57. Scientists are communistic.

58. Science is an attitude towards life and environment.

59. Our foremost scientists are primarily concerned with their own thoughts and ideas.

60. Science has done little for the average citizen.

61. Scientific truths are usually found by persons seeking economic gain.

62. The neglect of basic scientific research would be the equivalent of "killing the goose that laid the golden eggs."

63. Science receives too little serious attention in the mass media.

64. Scientists today are subject to too many governmental restrictions.

65. The engineer serves a more practical purpose in society than does the research scientist.

66. There is much self-satisfaction to be received from work as a scientist.

67. A scientist's life is full of adventure.

68. The average American home discourages girls from scientific careers.

69. Universities do little scientific research that is of immediate practical value.

70. Scientists do not need the physical stamina necessary for most other work.

71. Science helps us to understand our environment.

72. Scientific concepts and discoveries often bring about new sociological problems.

73. Scientists are against formal religion.

74. "Practical" politicians and business men disregard the advice of scientists.

75. Scientists often have physical deformities which render them unfit for other work.

76. Science and its inventions have caused more harm than good.

77. The social environment of the United States is hostile to the development of scientific talent.

78. One cannot have a normal family life and be a scientist.

79. The bulk of scientific research is carried on by devoted men and women without regard for their personal living or social relations.

80. Public interest in science is essential to the maintenance of scientific research.

81. Most of the basic scientific research done in our country is carried on by industry.

82. Many specific findings in science contradict the laws of God.

83. American scientists are largely responsible for our country's status among nations.

84. Scientists are essentially magicians, making two blades of grass grow where one grew before.

85. Industrial research is often carried on by teams of scientific workers.

86. Scientific work is monotonous.

87. The working scientist believes that nature is orderly rather than disorderly.

88. The modern world is dominated by science.

89. Scientists as a group are often condemned for the unpopular ideas and activities of a few fellow workers.

90. Scientists are often willing to sacrifice the welfare of others to further their own interests.

91. Scientists are usually unsociable.

92. Curiosity motivates scientists to make their discoveries.

93. The chief reward in scientific work is the thrill of discovery.

94. In high school, boys receive more encouragement to take science courses than do girls.

95. Americans place greater value on the practical applications of scientific discoveries than on the discoveries themselves.

APPENDIX D: ALLISON ADAPTATION OF "ALLEN ATTITUDE SCALE"

INSTRUCTIONS: Please give your reactions to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impression--the feeling that comes to mind as you read the item.

On the separate answer sheet fill in the letter which is the same as the letter of the answer you choose as best telling how you feel about the statement.

Fill between the lines under A if you completely agree with the item
Fill between the lines under B if you are in partial agreement
Fill between the lines under C if you are neutral
Fill between the lines under D if you partially disagree
Fill between the lines under E if you totally disagree

Example:

	A	B	C	D	E		
100.	‖	▮	‖	‖	‖	100.	In the springtime, Paris is more beautiful than New York. (Since B is filled in, this indicates that you are in partial agreement)

1. Science is not understood enough by most people.

2. Science is an orderly way of thinking.

3. Scientists are not often bothered with the places in which they have to work.

4. The development of new ideas pleases the scientist most.

5. Friends often discourage girls from taking high school science courses.

6. Science and the use of findings of science are necessary to the development of present day living together in the world.

7. Increased "atomic fall-out" or radiation resulting from bomb tests is a threat to the world.

8. Scientists are too narrow in their views.

9. The business world uses research as a means to make more money.

10. The use of what is known in science to make new businesses makes the world better.

11. The President's cabinet should be made larger by having a Secretary of Science.

12. Scientists and engineers should not be drafted into the Army, Navy, Marines, or Air Force.

13. The scientist will make more and greater discoveries when he has freedom to work on problems which interest him.

14. A scientist might well be thought of as a man who does not follow the ways of most people.

15. Scientists should be looked upon as people who can't be trusted.

16. Scientific experiments are carried on as a means to make more money.

17. To become a scientist you must be a very smart person.

18. Science requires creative activity.

19. Scientists are willing to change their ideas and thinking when shown new facts.

20. Scientists have very smart mothers.

21. Scientists are not modern in their views on music, art, and other things, so they are called "longhairs."

22. Since science is so hard to understand, we do not see how much it helps all the people in the world to come closer together.

23. Modern science is too hard for the average citizen to understand.

24. Scientists have too much power in our society.

25. Most things decided in the world are greatly due to science.

26. It is not fair to other people to favor the leading scientists.

27. The money won by a Nobel Prize winner in Physics should be at least the same as that given to T. V. stars and movie stars.

28. Dangers created by the increased use of atomic-bomb ("radio-active") materials make scientific work less attractive than before.

29. Scientists are shy, lonely people.

30. Loyalty checks and security clearances, to see if he is a spy, have seriously slowed down the work of many scientists.

31. For me, training for a career in science is not worth the time and effort required.

32. Science is first of all a method for inventing new things.

33. Scientists show their feelings more than other people.

34. Girls know little about fixing or working with machines, and therefore should not think of becoming scientists.

35. Scientists are honored persons who stand very high in popular fame.

36. To understand modern society fully, a person must understand the importance of science.

37. Scientists are an "odd" lot.

38. Science without mathematics is impossible.

39. Science is the greatest way to bring nations together.

40. Keeping up scientific work is needed to keep our nation alive.

41. The use of scientific findings is often held back by selfish people.

42. Scientific work is boring.

43. Scientific work in a country is greatly shaped by the amount of education the people of the country have had.

44. The free flow of scientific information among scientists is important to scientific progress.

45. Scientists show too much interest in their work.

46. I don't have the brains to have a successful scientific career.

47. The winning of the praise of the people he works with is one of the main aims of the scientist.

48. Scientific findings always lead to final truths.

49. Scientists are as concerned as are other groups with the rules and ways of the company for which they work.

50. Things done in the business world are based on what happens every day than on laboratory research.

51. The scientist can expect to gather little wealth as payment for his work.

52. Science is a man's world; there is little room in it for women.

53. Science is the greatest reason for the changes that happen so often in our way of living.

54. Scientists are "eggheads."

55. Scientific work requires long years of labor and giving up some pleasures.

56. A great research scientist gives little thought to how the things he discovers can be used in daily life.

57. Scientists are communists or "reds," which means they are friendly to Russia.

58. Science is a way of thinking about life and the places in which we live.

59. Our top scientists care most about their own thoughts and ideas.

60. Science has done little for the average citizen.

61. Scientific truths are usually found by persons trying to make money.

62. Not doing much basic scientific research would be the same as "killing the goose that laid the golden eggs."

63. Science receives too little serious attention on T. V., radio, and in the newspapers.

64. Scientists today are under too many rules by the government.

65. The engineer serves a more useful place in the world than does the research scientist.

66. There is much self-satisfaction to be received from work as a scientist.

67. A scientist's life is full of adventure.

68. The average American home discourages girls from scientific careers.

69. Colleges or universities do little scientific research that is of everyday use now.

70. Scientists do not need the physical strength needed for most other work.

71. Science helps us to understand the place in which we live.

72. Scientific ideas and discoveries often bring about new problems of different peoples living together in the world.

73. Scientists are gainst formal religion.

74. "Practical" politicians (government workers) and business men do not pay attention to the advice of scientists.

75. Scientists often have physical things wrong with them which make them unfit for other work.

76. Science and things invented by science have caused more harm than good.

77. The people and the way people live in the United States are against more people becoming scientists.

78. One cannot have a normal family life and be a scientist.

79. Most of the scientific research is carried on by loyal men and women without regard for their personal living or having friends and parties.

80. Public interest in science is needed to keep scientific research going.

81. Most of the basic scientific research done in our country is carried on by business.

82. Many of the findings in science go against the laws of God.

83. Our country's place among nations is largely due to American scientists.

84. Scientists are mainly magicians, making two blades of grass grow where one grew before.

85. Business research is often carried on by teams of scientific workers.

86. Scientific work is dull.

87. The working scientist believes that nature is orderly rather than not orderly.

88. The modern world is run by science.

89. Scientists as a group are often blamed for the unpopular ideas and activities of a few fellow workers.

90. Scientists are often willing to give up the good of others to further their own interests.

91. Scientists are usually not friendly.

92. Being curious or nosy is what stirs or inspires scientists to make their discoveries.

93. The chief reward in scientific work is the thrill of discovery.

94. High schools try harder to get boys to take science courses than they do girls.

95. Americans place greater value on the everyday uses made of scientific discoveries than on the discoveries themselves.

VITA

Roy William Allison, Sr. was born on January 2, 1925 in Lock Haven, Clinton County, Pennsylvania. He attended the Burnham Public Schools and was graduated from the Burnham High School in Burnham, Mifflin County, Pennsylvania in 1942. He received his Bachelor of Science in education from Shippensburg State Teachers College at Shippensburg, Pennsylvania in 1952 and a Master of Education degree in physics was conferred by The Pennsylvania State University, University Park, Pennsylvania in 1957.

He taught science and mathematics at the junior and senior high school level in the Marple-Newtown Joint Schools, Newtown Square, Delaware County, Pennsylvania from 1952 to 1959. He has served in the capacity of an elementary science consultant from 1959 to the present in the Marple Newtown School District, Newtown Square, Delaware County, Pennsylvania.

Mr. Allison served in the United States Army Air Force during World War II from 1943 to 1946.

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